SPARK

REPORT

STRATEGIC
PLANNING
FOR
APPLIED
RESEARCH
AND
KNOWLEDGE

Science
Council of
British
Columbia

MANUFACTURING AND MACHINERY

SECTOR PLANNING REPORT

PREPARED FOR

THE SCIENCE COUNCIL OF BRITISH COLUMBIA

JANUARY 1988

TABLE OF CONTENTS

		Page
1.	EXECUTIVE SUMMARY	1
2.	INTRODUCTION	2
3.	OBJECTIVE OF MANUFACTURING SECTOR PLAN	3
4.	THE MANUFACTURING INDUSTRY IN B.C.	6
5.	SCIENCE AND TECHNOLOGY IN B.C. MANUFACTURING	9
6.	RECOMMENDATIONS	15
7.	CONCLUSIONS AND IMPLEMENTATION	20
8.	EXHIBITS	

1. Strategic Plan for Manufacturing - Outline
2. Biomedical Engineering Devices Proposal
3. Manufacturing Technology Centre Proposal
4. Automation and Robotics Laboratory Proposal

1. EXECUTIVE SUMMARY

The manufacturing sector of the B.C. economy involves the major driving forces for economic growth and increased employment of the province namely: lumber, pulp and paper, chemicals, minerals, agriculture, aquatic resources and food, electronics and communications, manufactured goods and health products.

Science and technology must play a vital role with the 30 large manufacturers that dominate the resource industries and amongst the balance of the 4,000 small companies that make up the rest of manufacturing. Major opportunities exist in training people specifically in manufacturing, in providing a focus and a plan for science in manufacturing, encouraging technology transfer, developing robotics and automation, networking available support services and launching new initiatives in health care.

The committee believes that by supporting and encouraging these initiatives, the manufacturing sector can develop and bring increased revenue and jobs to the province.

2. INTRODUCTION

The Science Council of British Columbia established a series of sectoral planning committees in early September 1987, based on its already existing AGAR Grant committees, to identify opportunities for improving the application of science and technology to the economy of B.C. These committees comprise representatives of industry, universities, institutes and colleges, research institutions and government, and are to develop specific sectoral plans for the application of science and technology. The recommendations of each committee will then be reviewed and priorities established by Science Council and integrated into overall plans for science and technology by the Premier's Advisory Council on Science and Technology and by the provincial government.

These sectoral plans are aimed to identify key strengths and weaknesses and to make broad recommendations. Detailed investigations of specific opportunities or resolution of problems identified will occur subsequently once priorities have been established.

The following individuals were members of the Manufacturing and Machinery Sector Planning Committee:

Dale Cherchas	Dept. of Mechanical Engineering, UBC
John Dill	Engineering Science, SFU
Jim McEwen (Council Liaison)	Dept. of Biomedical Engineering, UBC
Jim Gregory (Chairman)	Canadian Occidental Ltd.
Carl Hunter	Wagner Engineering Ltd.
Ole Jensen	Integra Systems Inc.
Don McLean	McLean Engineering Ltd.
Ron Stern	Engineering Technology, B.C.I.T.
Gerry Stickland	Epic Data Inc.
Bob Williamson	RSI Robotic Systems
Blair Wilson	Canadian Manufacturing Association - B.C. Division

3. OBJECTIVE OF MANUFACTURING SECTOR PLAN

The committee specifically has developed the following objective:

"To produce a strategic sector plan for the enhancement of manufacturing industries in B.C. through applied research and development including contemporary manufacturing technology, methods and training."

3.1 Sectors Included

The Manufacturing and Machinery Sector includes a broad range of primary and secondary industries, namely:

- Auto Parts
- Consumer Goods
- Electronics - Communications
  - Industrial
  - Consumer
- Fabrication
- Food Processing
- Health Technology
- Materials - Fabrication
  - Forming
- Pulp and Paper
- Software
- Wood Products
- Plastics
- Resource Usage
- Apparel
- Transportation Equipment
- Fisheries
- Leisure Products
- Aquaculture
- Housing
- Robotics
- Secondary Manufacturing
- Metals
- Agriculture
- Minerals

There are two generic areas of manufacturing, namely continuous process and discrete part manufacture. Examples of the former include paper making, ore processing and of the latter, examples are sawn lumber, cans. etc.

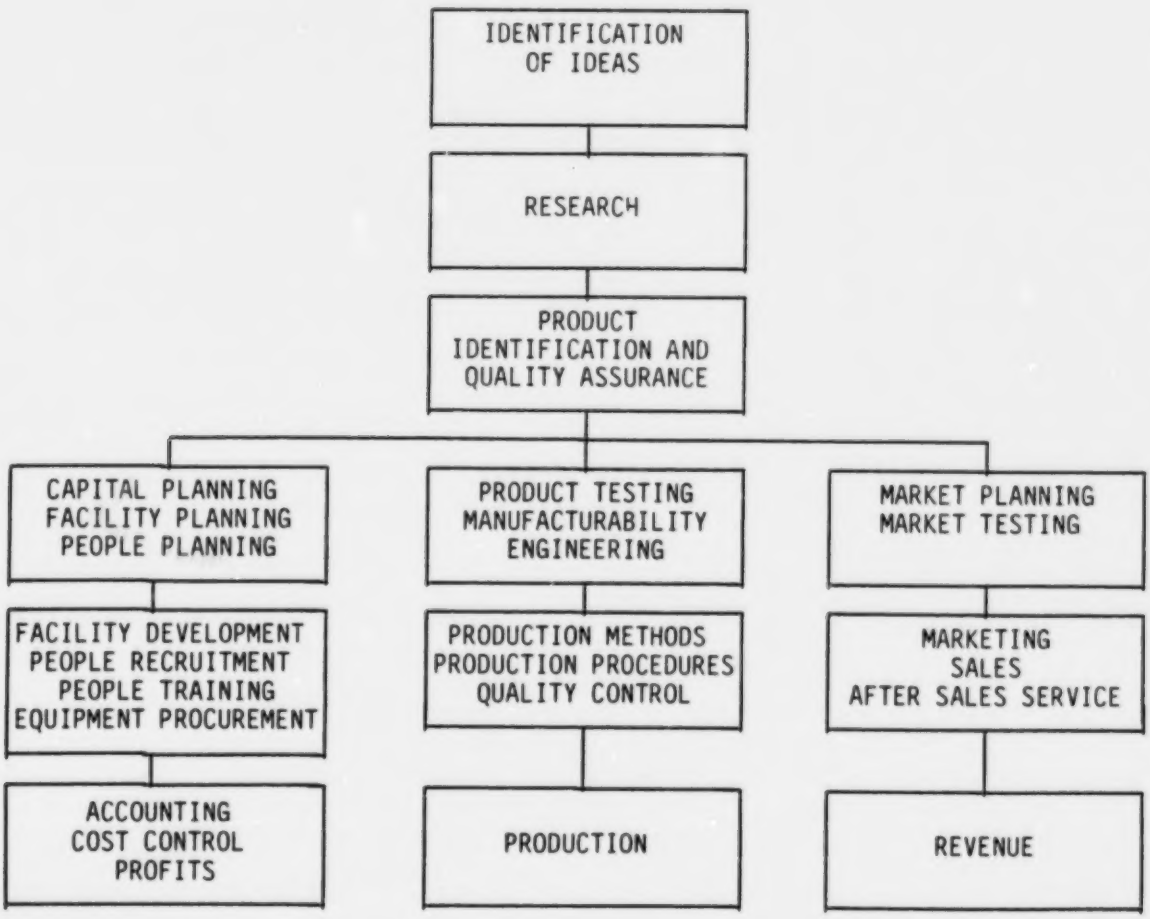
A number of these elements are important aspects of other sector plans, namely:

Wood Products, Pulp & Paper	-	Forests and Forest Products
Minerals, Metals	-	Mining and Metals
Agriculture & Food Processing	-	Agriculture
Aquaculture & Fish Processing	-	Aquatic Resources
Resource Usage	-	Energy
Electronics, Software	-	Information Technology

This committee aims its recommendations at the overall manufacturing sector embracing all aspects of manufacturing recognizing that other sectors will deal with specific elements applicable to their interests.

3.2 Scope of the Manufacturing Sector Plan

The committee recognizes that the application of science and technology to the manufacturing sector embraces many elements that are not always recognized as part of science and technology and wishes to make its observations and recommendations on all these subjects.



The committee recognizes that research and development has a place throughout this cycle and that each part is integral to the overall success of the manufacturing sector in B.C.

4. THE MANUFACTURING INDUSTRY IN B.C.

The manufacturing industry in B.C. is a very large segment of the Gross Domestic Product of the Province. The provincial government estimated statistics for 1986 show:

	Estimated 1986 $ Millions	%
Agriculture	705	1.4
Forestry	1,254	2.5
Fishing and Trapping	150	.3
Mining	1,355	2.7
*Manufacturing	7,075	14.1*
Construction	3,111	6.2
Utilities	2,057	4.1
Total Goods	15,704	31.3
Transportation, Communication	6,473	12.9
Wholesale and Retail	6,523	13.0
Finance, Insurance and Real Estate	8,380	16.7
Community, Business and Personnel Service	9,986	19.9
Public Administration - define	3,111	6.2
Total Services	34,473	68.7
TOTAL GOODS & SERVICES	50,177	100.0
Unallocated	4	
Gross Domestic Product	50,181	

4.1 Analysis of Manufacturing in B.C.

In 1985, the estimated annual sales and estimated annual growth rates for the manufacturing sector were:

	Sales ($000,000's)		Growth Rate (%)
Sawmilling	4,094	Aquaculture	59
Pulp and Paper	3,411	Fish	56
Food/Beverage	2,750	Oceanic Industries	50
Chemicals	1,525	Apparel	35
Metal Fabricating	808	Electronics	26
Fish	720	Computer Software	22
Veneer/Plywood	512	Plastics	19
Reman/Wood Products	512	Forest Products	13
Electronics	493	Marine	9
Machinery/Equipment	417	Aerospace	9
Plastics	337	Transportation Equip	9
Marine	330	Pulp and Paper	9
Apparel	209	Furniture	5
Transportation Equip	188	Machinery/Equipment	4
Furniture	113	Food and Beverage	1
Computer Software	60		
Oceanic Industries	45		
Aerospace	30		
Aquaculture	5		

Source: B.C. Ministry of Economic Development

This profile shows the very major impact of the large sectors of manufacturing, namely wood products, pulp and paper, food and chemicals, however, it also shows that major growth is occurring in the developing sectors of manufacturing where research and development has and can play a vital part.

4.2 Employment and Company Profile

The manufacturing sector in British Columbia employs some 170,000 people in approximately 4,000 companies.

Thirty of the largest companies account for 20% of the revenue, however after a few very large companies, the balance of the 4,000 quickly move to small organizations and basically miss out the medium sized companies which have been merged with larger organizations.

Ninety-two percent of the companies employ less than 100 employees and 58% employ less than 10. This profile impacts on the task of increasing the use of science and technology in the manufacturing sector. A very large proportion of this industry is represented by the approximately 3,700 companies with less than 100 employees who need particular attention and focus in terms of becoming aware of research and development and in implementing it in their own organizations.

4.3 Export Activity

A vital aspect of B.C.'s economy is its continuing need to export significantly in order to sustain and improve the living standard in the Province. In 1986, the $13 billion of B.C.'s goods exports were divided as follows:

Forest Products (all types)	$6.96B
Mining	3.99
Manufacturing (all other)	.98
Fisheries	.58
Processed Food	.18
Food and Agriculture	.17
Miscellaneous	.15
TOTAL	$13.01B

The markets served were:

U.S.	$5.5B
Asia	4.0
Europe	1.6
South America, C.A.	0.5
Middle East, Africa	0.1
	$11.7B

5. SCIENCE AND TECHNOLOGY IN B.C. MANUFACTURING

5.1 STRENGTHS

5.1.1 Basic Industries

The major segments of B.C. manufacturing namely wood products, pulp and paper, chemicals, and food processing with their annual sales of $11 billion, provide a solid base of manufacturing activity that requires the constant application of science and technology to maintain competitiveness and develop new and improved products. These activities provide a constant flow of opportunities for new and emerging manufacturers to support these basic industries with their products (reference section 4.1).

5.1.2 Growth Sectors

In addition, the Province is developing newer manufacturing industries with very high growth rates in aquaculture, ocean sciences, apparel, electronics, software, plastics, marine, new wood products, aerospace and transportation equipment (reference section 4.1).

5.1.3 Size Distribution

The very large percentage of small companies in the manufacturing sector can be a strength because usually these companies are owner-operated. This gives them the opportunity to pursue innovative ideas and support them in their organizations. These smaller companies have led the growth of many of the sectors with high growth rate and provide the potential for further growth.

5.1.4 Research and Development Resources

The universities, institutes, colleges, B.C. Research, NRC and industry have many of the facilities and people needed to undertake the required research and development. Funding has been available from federal and provincial sources and from industry.

5.1.5 Proximity to Markets

For many manufactured products, B.C. is well positioned near the major markets of the U.S. and the Pacific Rim.

5.2 WEAKNESSES

The major weaknesses in applying science and technology to the manufacturing sector of B.C. are:

5.2.1 Lack of Manufacturing Training and Education

Although some developments have occurred, there is insufficient specific manufacturing training in B.C. at the college, undergraduate and graduate levels. Additional specific courses and programs leading to diplomas, undergraduate degrees and post graduate degrees in manufacturing are required. There is only one accredited manufacturing university degree program in Canada, at McMaster University. The courses that do exist in B.C. are not yet reaching the small companies.

5.2.2 Lack of Technology Transfer Approaches

Because of the very large number of companies (4,000) and their preponderance of small owner-operated companies (58% under 10 employees), there is a major problem in transferring technology from the universities, institutes

and colleges to the manufacturing companies. Many do not have the time and resources to attend seminars and participate in research projects and activities and new innovative ways of reaching these people must be found.

5.2.3 Absence of Start-up Help

Many small companies need assistance in a hands-on environment to test their manufacturing ideas and to develop their concepts to the manufacturing stage. They also need an environment to become aware of new approaches and to try them without having to invest their own capital.

5.2.4 Market Planning, Marketing, Accounting, Entrepreneurship

Although many innovative ideas for manufactured products emerge within B.C., many do not make it past the idea stage or from the very small company to the mid-size range. A lack of planning, management, marketing, accounting, entrepreneurship, knowledge and skills at senior management levels is a major contributor to this reduced success. Assistance in these areas to start-up companies and inclusion of these topics in training courses is required.

5.2.5 Lack of Awareness of B.C. Manufacturing Resources

A common concern among B.C. manufacturers is their lack of knowledge of possible infrastructure and support organizations in B.C. who could participate with them in manufacturing a product, particularly if it is a multi-process product. This lack of awareness causes the manufacturers to turn to Toronto, Japan, Taiwan, Hong Kong and the U.S. for this participation in the manufacturing process.

5.2.6 Health Products

The Province presently imports a significant part of its health related products which are a large part of the provincial expenditures. An opportunity exists to focus on biomedical devices and health products to capitalize on the existing demand and strengths of the research community and the capabilities of the industrial companies in this area. In order to capitalize on this opportunity, sterilization facilities must be developed in B.C.

5.2.7 Robotics and Automation

The existence of a large resource industry, including value added manufacturing in the Province in forestry, wood products, mining, fishing and agriculture indicates a need to focus on the manufacture of robotic and automated devices to support and enhance these industries. This focus can draw on the research capabilities in the universities, institutes and colleges, the resource companies and the supplier community. This initial focus on robotics for the resource industries would have simultaneous benefits for other manufacturing industries.

5.2.8 CAD CAM Opportunities

The application of CAD CAM techniques to manufacturing activities in the Province is being pursued in Victoria, at BCIT and in Prince George. These initiatives need further resources and assistance to develop specific B.C. related applications and to extend their use with the community of 4,000 manufacturing companies in B.C.

5.2.9 R&D $'s

British Columbia is at the low end of the table of developed economies in terms of percentage of G.P.P. spent on R&D in 1985 (0.7% compared to other countries at 2.0% - 3.0% and Canada as a whole at 1.4%). The manufacturing sector requires a higher input of R&D $'s to keep its participants world competitive and to develop new and innovative products. As a minimal first step towards improving this situation, the manufacturing sector should target to reach the Canadian percentage.

5.2.10 Science and Technology Plan

The committee identifies that no overall strategic plan exists to focus science and technology on the manufacturing sector and that no resources (i.e. people) are charged with the responsibility of developing such a plan and then ensuring that it is implemented.

5.2.11 Shortage of Proposals for Science Council Grants

A weakness exists in communicating the availability of grants for research and scholarships to the manufacturing sector.

5.3 OPPORTUNITIES

The opportunities available to the manufacturing sector in terms of developing a better impact from science and technology are:

1. Development of education and training courses in manufacturing at diploma, undergraduate and graduate level.
2. Development and implementation of an appropriate technology transfer program.
3. Development of a small business manufacturing support centre.

4. Development of education and training and assistance programs in planning, marketing, management and accounting and entrepreneurship for manufacturers.

5. Development and implementation of a program for communication amongst B.C. manufacturers.

6. Focussing on biomedical devices and health products development and manufacture.

7. Focussing on robotics and automation for the resource industries.

8. Continuing to support CAD CAM developments and implementation for specific B.C. applications.

9. Developing and implementing a strategic plan for science and technology in manufacturing and identify a 'champion' to make this happen.

10. Increasing the R&D monies available to the manufacturing sector and increasing the communication of this research funding to the manufacturing companies, particularly the smaller organizations.

6. RECOMMENDATIONS

In order to increase the impact of science and technology on the vital manufacturing sector of the province's economy, the committee evaluated the opportunities outlined in Section 3 and recommends the following, listed in order of priority. The committee strongly recommends that industry continue to be involved in all of these initiatives, either by direct participation or on advisory boards.

1. The development and implementation of an integrated strategic plan for science and technology in manufacturing and the identification and appointment of a 'champion' to make the plan happen.

2. The launching of a major focus on biomedical devices as an area of excellence in B.C. and a potential new diversification in the province's economy.

3. The development and implementation of manufacturing specific education and training programs at colleges, institutes and universities, the implementation of technology transfer programs and a focus on planning, marketing, management and entrepreneurship in all manufacturing training and education.

4. The development and implementation of a joint SFU/BCIT small manufacturing technology centre to assist the large number of small manufacturers to test their ideas and get started and the spreading of this concept to other colleges through the province as it becomes accepted and useful.

5. The launching of a world class robotics and automation initiative focussed on the resource industries' needs and the expertise at UBC.

6. The implementation of innovative approaches to provide a network of contacts and information for B.C. manufacturers so that they become aware of B.C. support resources that can participate in their manufacturing process.

7. Continuing the development of applications for CADCAM use in specific manufacturing industries.

8. Inreasing the R&D funding for manufacturers and communicating more effectively the availability of these funds.

1. Strategic Plans and Resources

The committee recommends that strategic plans for science and technology be implemented and that responsibilities and time frames be established for all key actions. This strategic plan must include marketing considerations as these are vital in this sector. There is an urgent need for coordination, cooperation and collaboration to make an impact. In addition, the committee recommends that an experienced, credible manufacturing specialist be recruited jointly by the CMA and the Science Council of B.C. to act as 'champion' for manufacturing science and technology in B.C. to make sure the recommendations of this report happen. This 'champion' must be knowledgeable of small companies, sensitive to B.C. issues and have linkages to knowledge outside of B.C.

2. Biomedical Engineering

The committee supports the initiative developed by industry, the hospitals and UBC to resource and expand a focus on biomedical engineering. The province has a demand for these developments, there is a large world-wide market, the leaders in required expertise are located in the province and the parties involved need to cooperate and coordinate in the proposed biomedical engineering initiative. There is a need to develop a sterlization plant in B.C. to move the pharmaceutical and medical devices and supplies industry forward.

3. Manufacturing Specific Training

Manufacturing courses need to be developed and expanded at the colleges, institutes, the universities (graduate and undergraduate degree programs including provision for coop students) and in industry through

continuing education. Specific training is also required to increase the number of skilled tradesmen and upgrade skills of existing tradesmen. The apprenticeship program should be reinstated at a comparable level to competitive programs with continued funding. These courses must focus specifically on manufacturing as an area of specialty but they must also include major elements of marketing, planning and management so that graduates who become involved in the large number of small companies in the province can comprehend the full business impact of their manufacturing activities. Continuing education programs in manufacturing and management need to be developed and implemented for those involved in manufacturing.

In addition, specific approaches involving the colleges, institutes, universities, research organizations and industry must be developed to better transfer technology to the companies involved in manufacturing in B.C.

4. Manufacturing Technology Support Centre

The committee supports the initiative to utilize existing facilities at BCIT and SFU for a small manufacturers technology centre. This support centre will have an Advisory Board with representation of industry to ensure that it is always needs driven. This centre is intended to provide teaching facilities, support services and training, expertise, education, research and technology transfer and access to advanced equipment. This will enable start-up manufacturers and those with limited facilities and equipment to bring their manufacturing ideas and problems into an environment where they can physically test them with experienced help at hand. Suppliers of equipment and systems will be encouraged to use the centre to display their products, training will be

provided and a focus provided for the small, start-up manufacturers to develop their ideas to the manufacturing stage. The possibility of linking this initiative with the Advanced Systems Institute will be explored. As the centre becomes proven, this concept can be extended to include other colleges throughout the province.

5. Automation and Robotics Laboratory

The committee supports this initiative which will involve a focus on the robotics and automation needs of the resource industries and involve resource organizations and companies, expertise now available at UBC and the resources of the Advanced Systems Institute of B.C. and particularly the Centre for Integrated Computer Systems Research (CICSR) at UBC.

This focus involving the resource industries and the University will allow the resource industries to identify their research needs involving robotics and automation and will pull together the various elements at the university with required expertise. The projects will focus on the generic tasks of materials handling and manipulation for the resource industries and robotic assembly and inspection, arc welding and robotic machinery operations for the secondary manufacturing sector. The tie-in to the Advanced Systems Institute will allow these developments to be disseminated to a broader group in the province. In addition, industry organizations such as Feric, Forintek, Paprican, Mining Association, etc. will be involved to increase industry involvement.

The plan is for this focus on robotics in the resource sector to expand, in time, to enhance the other sectors of the provincial economy to fully utilize the emerging technologies identified in the resource industries.

6. Network and Communications

Because of the very large number of small companies in the B.C. manufacturing sector, it is extremely difficult for each of them to know the complementary activities available to them in B.C. Because of this, many of the companies involved in complex manufacturing involving a number of materials and processes go outside of the province for participants in their manufacturing process. They are unaware in many cases that the participation or support services they require are located in the province.

This problem is not easy to address, the committee believes that although directories, both hard copy and computer based, may assist, the real networking occurs when people meet others face to face. Therefore the recommendation is to charge and fund CMA, Science Council of B.C., universities, institutes, colleges and industry associations with the task of regularly calling seminars, trade shows, open houses, dinners, lunches and site visits. This effort will cause manufacturers to meet each other and to identify participants and support services to assist their production activities. In addition, information on support services available from outside B.C. is also required for these manufacturers.

The proposed manufacturing science and technology champion could be a proactive broker to make sure these contacts occur on a one-on-one basis. In addition, the committee feels that a comparison activity to the 'B.C. Trade Offices' overseas is needed in B.C. itself to ensure that opportunities for B.C. manufacturers are not overlooked.

7. CADCAM

Continue the development of specific CADCAM research applications for B.C. industries and particularly transfer this technology to a larger percentage of B.C.'s manufacturers. This work is underway in conjunction with industry at BCIT, at CART in Prince George, at the University of Victoria and at Camosun College.

8. Funding and Support

Gradually increase the funding from all sources for manufacturing research and development up to the Canadian average of 1.4% of Gross National Product. Particularly launch a communications and assistance program so that a larger percentage of the 4,000 manufacturers in the province apply for and obtain research funding, particularly from the Science Council of B.C. Investigate a first user reduction program where industry shares the risk and pays back the funding if the project succeeds. Provide small companies with support for funding, understanding of financial organizations and tax incentives. Support CMA investigations of tax incentives for R&D.

7. CONCLUSIONS AND IMPLEMENTATION

In order to implement the important recommendations outlined in this report, the following actions are required:

1. Strategic Plan and Focus

Charge the Science Council of B.C. with further development of the strategic plan for science and technology in manufacturing. Obtain funding for a 'Champion for Science in Manufacturing' and recruit an individual.

2. Biomedical Engineering

Provide approval and funding for the specific proposal attached.

3. Manufacturing Training, Education and Technology Transfer

Invite proposals from the colleges, institutes and universities for manufacturing specific education and training at diploma, undergraduate and graduate levels, also invite proposals for technology transfer approaches, particularly to the many small companies.

4. Manufacturing Technology Centre

Provide approval and funding for the specific proposal attached.

5. Automation and Robotics Laboratory

Provide approval and funding for the specific proposal attached integrating this if possible with Advanced Systems Institute initiatives.

6. Network and Communications

Charge CMA, Science Council of B.C. and academic organizations with sponsoring specific funding that will bring manufacturers together. Have the 'champion' take proactive steps to make it happen.

7. CADCAM

Support initiatives for the development and delivery of CADCAM technology to manufacturers.

8. R&D Funding

Increase the availability of R&D funding to the manufacturing sector through national and B.C. agencies. Improve the communication of these sources of funds to the large number of small companies.

EXHIBITS

1. Strategic Plan for Manufacturing - Outline
2. Biomedical Engineering Devices Proposal
3. Manufacturing Technology Centre Proposal
4. Automation and Robotics Laboratory Proposal

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MANUFACTURING & MACHINERY SUB COMMITTEE

15 JANUARY 1988

The attached industry profile is a listing of the generic requirements to successfully manufacture, and a means of rating each industry segment in B.C. Only the electronics industry is rated as my B.C. knowledge is limited to my experience with two local electronics firms.

The market and marketing is assumed in each instance to be in place.

I recommend that a full time task force be established with the following mandate:

1) Complete the manufacturing requirement by industry segment.

2) Prioritize the weaknesses in terms of need and value added.

3) a) Establish programs jointly with government, industry and academia (professional societies).

   b) Programs must include responsibility, timetable and budget.

The infrastructure is in place in B.C. to provide innovative products and technology. The follow on jobs that can be available in the manufacturing sector, require the joint commitment of government, industry and academia to establish world class manufacturing resources in B.C.

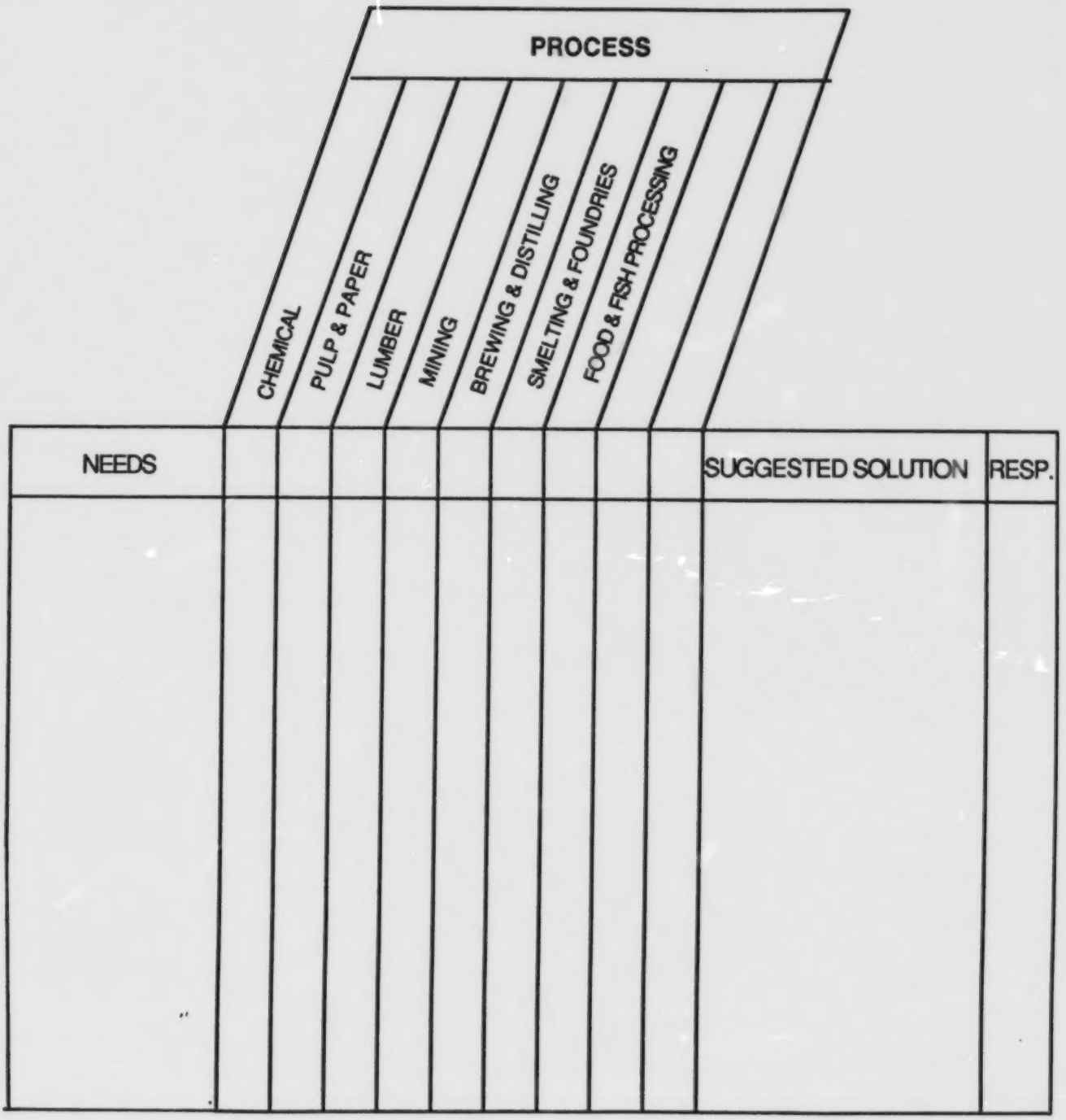
J. Chan

per. Gerry Stickland,
V.P., Operations

MACHINERY & MANUFACTURING SUBCOMMITTEE

PROFILE OF INDUSTRY

STRENGTHS & WEAKNESSES



MACHINERY & MANUFACTURING SUBCOMMITTEE

PROFILE OF INDUSTRY
STRENGTHS & WEAKNESSES

DISCRETE -PART MANUFACTURING

S = STRONG
W = WEAK
A = ACCEPTABLE
N/A = NOT APPLICABLE

MANUFACTURING REQUIREMENTS		ELECTRONICS & COMM.	MACHINERY	CLOTHING	AIRCRAFT	AUTOMOTIVE	PLASTICS	FABRICATION (METAL)	WOOD PRODUCTS	PRINTING & PUBLISHING	SUGGESTED SOLUTION	RESP.
SKILLS												
DESIGN												
-Functional	S											
-Specific skills not available. Radio frequency surface mount, etc	W										-Quantify need and establish program	
-Project Mgm't (new prod. intro)	W										-Establish program	Academia & Industry
-Design for manufacture & testability	W										-Quantify need and establish program	Academia & Industry
-Design for quality & reliability	W										-Quantify need and establish program	Academia & Industry
-Design for shipping	W										-Quantify need and establish program	Academia & Industry
-Packaging Design	W										-Quantify need and establish program	Academia & Industry
MANUFACTURING MANAGEMENT												
-Manufacturing Management	W										-Expand BCIT Operations Mgm't program & option in Engineering programs	Academia & Industry
-Production/Ind Eng./Mtm.	W										-Quantify need & establish program	Academia & Industry
-Test Engineering	W										-Quantify need & establish program	Academia & Industry
-Education in Quality	W										-Quantify need & establish program	Academia & Industry
-Manufacturing Mgm't Accounting	W										-Work with CA & CMA to incorporate in their program	Gov'l & Industry
-Skilled Service/Maintenance men for new technology I.e. Robotics, Numerical Control	W										-Greater emphasis on extention programs	Academia & Industry
-Ongoing Development & Training	W										-Day release, etc.	Academia & Industry
NEEDS												
-CAE	W										-Quantify Need/Application and Establish Program	Government Academia & Industry
-CAD	W											
-CAM	W											
-ATE	W											
-Robotics	W											
-Flexible Mfg.	W											
-MRP	W											
FINANCE/FUNDING												
-Venture Capital	W										-Encourage risk taking	-Gov'l
-Business Planning	W										-Test business plans for practicality/doability before funding	-Gov'l
-Training Expense	W										-Treat as an asset & provide incentive to do	-Gov'l & Industry
-Incentives to Manufacture in B.C.	W										-Tax holidays, etc.	-Gov'l
-Seed Money	W										-Gov'l programs	-Gov'l

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OCT 20 1987
BIOMEDICAL
ENGINEERING

August 18, 1987

PROPOSAL FOR A BIOMEDICAL ENGINEERING INITIATIVE AT THE UNIVERSITY OF BRITISH COLUMBIA

CONTENTS

		Page
EXECUTIVE SUMMARY		2
1.	INTRODUCTION	2
2.	RESEARCH FOCUS	3
3.	EXISTING STRENGTHS	4
4.	SUPPORT FROM INDUSTRY	6
5.	DEVELOPMENT PLAN	7
	5.1 Staff	7
	5.2 Organization	8
	5.3 Space	9
	5.4 Equipment	9
6.	EXPECTED BENEFITS	10
7.	CONCLUSIONS	12
	Appendix I. Needs and Opportunities	13
	Appendix II. Faculty Involved in Biomedical Engineering Research	18
	Courses Related to Biomedical Engineering	19
	Appendix III. B.C.-Based Companies Currently Manufacturing and/or Developing Medical Devices	22
	Appendix IV. Additional B.C.-based Firms Having Potential Interest in the Development/Manufacture/Financing of New Medical Devices	26
	Appendix V. Selected B.C. Agencies which could Benefit from a Biomedical Engineering Initiative	30

EXECUTIVE SUMMARY

It is proposed to establish a Biomedical Engineering Initiative at UBC, having an initial focus aimed at the need-oriented development of new medical devices and related technology. This activity will strengthen already-existing research at UBC, and will promote the establishment of new interdisciplinary research within the University, particularly between the applied sciences and the health sciences, as well as within the health care services and industrial sectors in B.C. Close collaboration between UBC and its five affiliated teaching hospitals, as well as collaboration with relevant provincial agencies, industry and other institutions, will be emphasized. UBC is the logical centre for this much-needed activity in biomedical engineering because it has the Province's only medical faculty and related health sciences faculties and programs, because a nucleus of pertinent research and development activities already exists, and because an informed network involving UBC, various teaching and research hospitals in the province, and related agencies and industries has already been initiated. The proposed Biomedical Engineering Initiative will require an annual operating budget of approximately $700,000, a capital equipment budget of $225,000, and space of approximately 6,500 NSF. It is anticipated that the knowledge, graduates, interactions, and industrial activity arising from the biomedical engineering activity will have significant educational, economic and social benefits for the people of the Province of British Columbia.

1. INTRODUCTION

The rapid pace of technological advancement in health care has made essential inter-disciplinary cooperation in research and collaboration with the health care system in general, and hospitals in particular.

Significant research expertise already exists at UBC in the area of biomedical engineering, however the activities tend to be diffuse, organized along Departmental lines and not focussed enough. Also the number of faculty involved is too low to assure a reasonably broad covering of the field and achieve significant economic impact.

It is being recommended that the focus of biomedical engineering activities at UBC be on the need-oriented development of new medical devices and related technology. This would be a unique mandate in Canada. There is currently no other organized effort along these lines at any Canadian university, despite the existence of long-standing and innovative research groups in biomedical engineering at the University of New Brunswick, McGill University, and the University of Toronto.

2. RESEARCH FOCUS

The proposed strategy is is to emphasize one area of biomedical engineering, and to use that as an engine to drive related spin-off activities and research. A unique focus for biomedical engineering in British Columbia would be the development of new medical devices and related technology to meet urgent and unmet needs of the health care system. In this context "medical devices" are broadly defined as tools or machines designed for specific diagnostic or therapeutic functions, and the definition is meant to include transducers and instrumentation, electrical and mechanical hardware, related software and biomaterials.

The general goal in developing such medical devices and related technology would be: (1) to improve the quality of diagnosis and treatment; (2) to control or reduce the costs of such diagnosis and treatment; and (3) to reduce the exposure of patients and staff to hazards.

The Biomedical Engineering Initiative would establish capabilities for research, development, design, system integration and manufacture, and for providing services in both the public and private sectors. The public sector needs biomedical engineering expertise for hospitals, federal and provincial governments, and universities and post-secondary institutions. The private sector currently requires biomedical engineering expertise in order to establish a viable medical device industry in Canada. Excellent opportunities also appear to exist for adapting the expensive medical technologies that are now widely used in North America for appropriate less costly use in developing countries, thereby creating major export opportunities for Canadian manufacturers.

A detailed summary of the nature and magnitude of the needs and opportunities related to the development of medical devices and related technology is given in Appendix I. With regard to the economic implications, the Department of Regional Industrial Expansion (DRIE) has recently completed an evaluation of the health industry in Canada, and has in particular studied opportunities for health industry development in western Canada. DRIE has estimated that approximately $40-billion are spent annually in Canada on health care, of which $2-billion are spent on medical devices in Canada. Of this total, 80% (or $1.6-billion) of the expenditures for medical devices are for imported products. Considering western Canada as an economic entity, $12-billion are spent on medical devices. In British Columbia, a total of $4.7 billion is spent annually on health care, of which an estimated $236-million is spent on medical devices. In British Columbia, the DRIE study has indicated that there is a major disparity between the expenditures on medical devices and the location of medical device industries. This is best illustrated by Figure 1, which shows that western provinces account for 31% of the expenditures for health care in Canada, but only 13% of Canadian health care industries are located in western Canada. Clearly, a need and an opportunity exists to develop a health care products industry in British Columbia, for the purpose of economic growth and industrial diversification. The establishment of a Biomedical Engineering Initiative at UBC should be a key element of such a strategy.

3. EXISTING STRENGTHS

There are activities in biomedical engineering presently being carried out within the departments of Electrical Engineering, Mechanical Engineering, Metallurgical Engineering, Physics, Engineering Physics, Chemical Engineering and the Faculty of Dentistry at UBC. Some undergraduate and graduate courses offered cover topics relevant to the biomedical engineering field. The list of courses offered and faculty members involved is given in Appendix II.

Significant resources are available in the hospitals. For example, the annual operating budget of the Vancouver General Hospital is over $170-million. The annual operating budget of

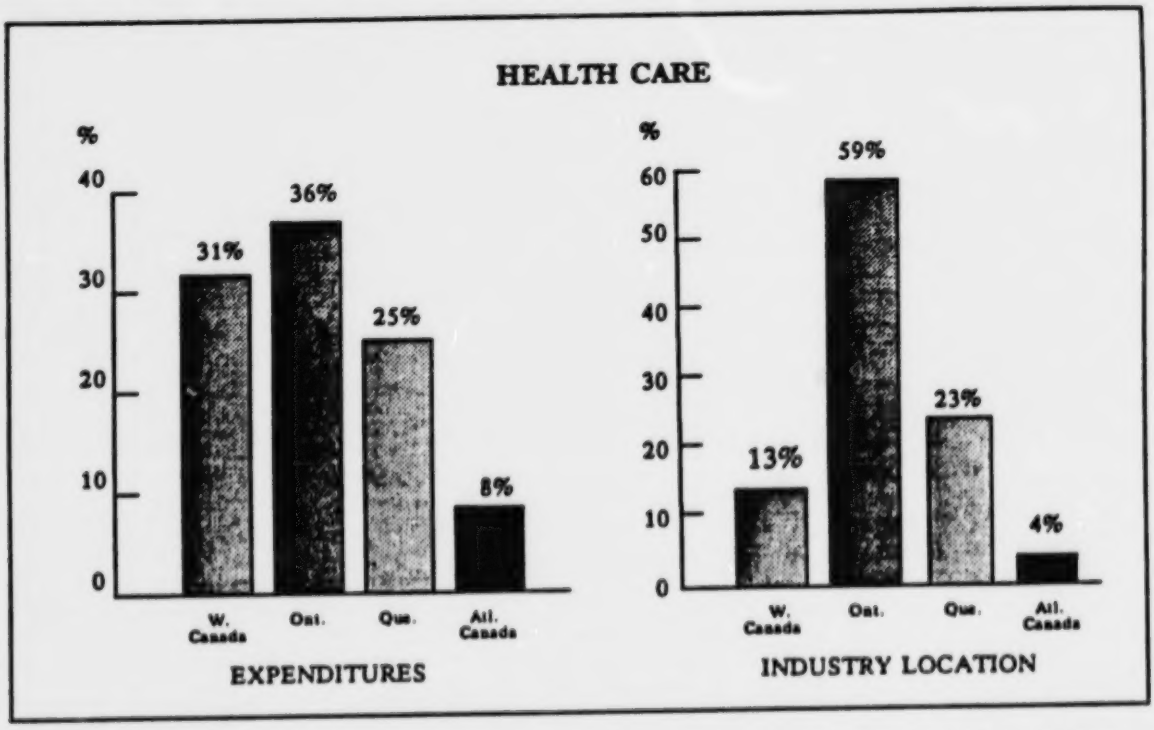


Figure 1: Health care expenditures versus industry location in Canada (from DRIE)

the UBC Health Sciences Centre Hospital is more than $40-million. Such hospitals allocate approximately 5 percent of their operating budgets for capital medical technology (not including disposable devices, accessories and supplies), and have annual capital budgets for major new technology equal to an additional 2% of their operating budgets. The resulting accumulation of medical technology is considerable: at these two hospitals alone, the replacement cost of capital medical technology is well over $25-million. Both hospitals are already affiliated with UBC, as are three other teaching hospitals and additional institutions such as the G.F. Strong Rehabilitation Centre.

Vancouver has:

- the best infrastructure of hospital-based biomedical engineering departments in Canada for the identification of opportunities for the need-oriented development of new medical technology, and for the evaluation of such technology as it is being developed;

- convenient access to a wide range of tertiary and quaternary facilities for diagnosis and treatment;

- a recent track record and history of success in specific areas of medical-device development which is second to none in Canada; and

- a high level of interest on the part of talented and academically first-class undergraduate and graduate students in engineering who are keen to become involved in such an initiative.

While some may point to the lack of an established medical device manufacturing industry in British Columbia, the fact there is a very large "hidden" health services industry having annual expenditures between $3.3 and $4.7-billion dollars in B.C., which could serve as the base from which to support the proposed initiative for the need-oriented development of new technology.

4. SUPPORT FROM INDUSTRY

Support from industry for biomedical engineering can be grouped into the following general categories:

- B.C. companies and organizations now involved in the manufacture, development and marketing of medical devices and related health care products (see Appendix III for a list of 25 companies known to UBC);

- companies and organizations in British Columbia which are presently not involved, but which could become involved in the development, manufacture and marketing of medical devices and related systems and products (see Appendix IV for a list of 30 companies known to UBC);

- multinational health care companies wishing to hire qualified engineering staff or wishing to identify a world product mandate suitable for British Columbia; and

- the health service industry in British Columbia, i.e. hospitals, rehabilitation centres and health care delivery organizations (see Appendix V for a list of centres and organizations which have already expressed interest).

5. DEVELOPMENT PLAN AND RESOURCE REQUIREMENTS

In order to start a concentrated effort in the area of biomedical engineering it is necessary to coordinate existing activities in this field, as well as to assure their focus and breadth. The following resources will be required.

5.1 Staff

A senior academic expert in the field of biomedical engineering, experienced in the development of medical devices, should be appointed to act as coordinator of the program. Four new appointments (2 in Electrical Engineering and 2 in Mechanical Engineering) at the assistant or associate professor level are required in order to assure an appropriate breadth of graduate teaching and supervision of graduate students, in M.A.Sc. and in Ph.D. programs. Two to three research associates in the health sciences will also be required and it is anticipated that appointments to these positions will be made for terms of one or two years. Also, three research engineers or research associates are required in Electrical and Mechanical Engineering. Support staff composed of two biomedical technologists (one in Electrical Engineering and one in Mechanical Engineering) and one secretary will also be needed.

The senior academic coordinator and the research associates in Health Sciences might be joint appointments between the Faculty of Applied Science and the Faculty of Medicine. The other seven appointments would most likely be in Electrical Engineering and Mechanical Engineering. The budget for the staff required above is estimated as follows.

Position	No.	Salary($)	Total($)
Senior Academic Coordinator	1	75,000	75,000
Assistant/Assoc.Professors (2 in Electrical Engg., 2 in Mechanical Engg.)	4	45,000	180,000
Health Research Associates (in Health Sciences Dept.)	2-3		150,000
Engineering Research Assoc. (in Electrical Engg. and Mechanical Engg.)	3	40,000	120,000
Biomedical Technologists (1 in Electrical Engg., 1 in Mechanical Engg.)	2	32,000	64,000
Secretary/Receptionist	1	20,000	20,000
		TOTAL:	$609,000
Benefits @ 15%			91,350
		TOTAL:	$700,350

5.2 Organization

It is proposed that the Biomedical Engineering Initiative be established and coordinated by an advisory committee having approximately equal representation from the applied sciences and health sciences. The suggested composition of the advisory committee is as follows: the Coordinator of the Biomedical Engineering Initiative; the Dean of the Faculty of Applied Science, or his designate; the Dean of the Faculty of Medicine, or his designate; the Coordinator of Health Sciences, or his designate; a faculty member from Electrical Engineering and one from Mechanical Engineering who are active in a relevant area of biomedical engineering; a faculty member from one of the health sciences faculties who is active in a relevant area; the Director of the combined Biomedical Engineering Department of the Vancouver General Hospital and UBC Health Sciences Hospital; the Director of the UBC Clinical Engineering Program; and at least one ex-officio representative of B.C.-based firms engaged in the development and manufacture of medical devices or related technology. It is proposed that the chairman of

the advisory committee be chosen from among the health sciences representatives, in order to maintain a balance between the health sciences and the applied sciences.

5.3 Space

A total of 6,500 net sq. ft. of core space is required for the Biomedical Engineering Initiative. It is anticipated that at least an equal amount of additional non-core space will be made available by collaborating hospitals, institutions, agencies and firms. Preferably, the core space will be located at UBC close to existing space of the Faculty of Applied Science. It may be most cost-effective to provide this core space in a new building. Although space close to the existing facilities of the Faculty of Applied Science is preferred, alternate core space might be arranged on an interim basis in conjunction with one or more of the teaching and research hospitals and institutions associated with UBC.

Details of the space requirements are given below.

Function	Unit Size (NSF)	Unit Number	Total (NSF)
Labs - R&D	250	11	2,750
Support - Electronics	500	1	500
- Mechanical	500	1	500
- Computers	500	1	500
Supplies & Components	250	1	250
Offices	150	10	1,500
Secretary/Reception	250	1	250
Seminar/Meeting Room	250	1	250
		TOTAL:	6,500

5.4 Equipment

An equipment budget of approximately $225,000 is required for the Biomedical Engineering Initiative. Of this total, approximately $125,000 will be allocated for instrumentation, electronic apparatus and mechanical apparatus for the development, design and evaluation of prototypes of new medical devices. An additional amount of $100,000 is required for equipping new facilities with microcomputers, automated workstations, accessories and peripheral devices for automated design, real-time data

acquisition and analysis, modelling and other functions related to the development and evaluation of new medical devices. It is recognized that the incremental funds being sought for equipment are very modest, but it is anticipated that the collaborating hospitals, institutions and firms will provide sufficient access to additional test equipment, prototype fabrication equipment and related systems and facilities having a minimum replacement cost of over $2-million. In addition to this equipment, teaching hospitals and institutions affiliated with UBC will also provide sufficient access for the Biomedical Initiative to the existing base of medical technology in those hospitals and institutions estimated to have a current replacement cost of more than $25-million.

6. EXPECTED BENEFITS

The primary benefit arising from the Initiative would be the development and availability of need oriented technology which would be of use in British Columbia, as well as elsewhere in Canada and the world, to help control or reduce the costs of diagnosis and treatment, and to help reduce the exposure of patients and staff to unnecessary hazards.

Another benefit from this Initiative would be the availability of well trained engineering graduates suitable for careers in research, development, design, system integration and manufacture, and services in both the public and private sectors. This would include providing individuals with expertise suitable for high-technology research and development, emerging growth companies, new ventures in medical technology, hospitals, federal and provincial governments, regulatory agencies, and universities and post-secondary institutions.

Significant economic benefits can be expected as spin-off activities. Historically, many of the most successful medical device companies in the world today began as a collaboration between a few individuals associated with universities, hospitals and the private sector. Even in recent years, despite the great increase in the sophistication of medical technology and in the vertical integration and consolidation of companies within the health care industry, many exciting and highly successful medical device companies continue to emerge from similar collaborations.

Each such successful venture succeeds in tangibly improving the quality of health care, while at the same time generating satisfying and exciting career opportunities for individuals in engineering and health care disciplines. This helps complete the cycle by which the community, which initially supported the university financially, receives benefits in terms of increased economic activity, increased quality of health care and an increased number and variety of challenging employment opportunities.

In the Vancouver area, there have recently been some clear indications that the same pattern of success, growth and economic activity is achievable here. For example, a microprocessor-based surgical tourniquet which was developed as a result of collaboration between James McEwen, a biomedical engineer, and Robert McGraw, an orthopaedic surgeon, is now in widespread use in more than 25 different countries throughout the world. Every day several thousand of these medical devices, which emerged from a research and development program in B.C., are used to improve the quality and safety of surgical procedures at major teaching and research hospitals in Canada, the United States, Japan and Europe. More recently another collaborative effort between biomedical engineers and individuals in health science faculties at UBC, in conjunction with a B.C. company, Andronic Devices Ltd., has resulted in the development of innovative medical and surgical robotic systems and world recognition that this effort is in the forefront of a new generation of advanced medical devices with significant economic potential. Recently, Andronic Devices began producing the first batches of advanced medical devices resulting from their research and development program, which will be manufactured in B.C. and marketed worldwide by a premier multinational corporation. In different areas, a driving simulator for the evaluation of disabled drivers, developed by Charles Laszlo (UBC) and Cecil Hershler (G.F. Strong Rehabilitation Centre), is about to enter the limited production stage, and the first CAD/CAM system for automated prosthesis design, which was developed and manufactured by Shape Technologies Inc. (a B.C. spinoff company from the UBC Medical Engineering Resource Unit at Shaughnessy Hospital), has been marketed successfully.

The proposed Initiative in Biomedical Engineering will meet not only a provincial need but also a national one as there is no other organized effort along these lines at any Canadian university, despite the existence of long-standing and innovative research groups in biomedical engineering at universities in other provinces.

7. CONCLUSIONS

We recommend that action be taken now to significantly enhance activities in the area of biomedical engineering. The focus of activities should be development of new medical devices and related technology. Research hospitals and existing flourishing biomedical engineering departments at these hospitals in Vancouver, together with thriving engineering and health science faculties on campus are important elements for the success of this initiative.

APPENDIX I

Needs and Opportunities

This appendix provides background information to illustrate the nature and magnitude of the opportunities which could be exploited by a Biomedical Engineering Initiative at UBC.

Some of the information contained in this appendix has been derived from a market study released recently by the Ontario Centre for Microelectronics (CCM) of Ottawa, entitled Microelectronics Opportunities in Health Care. According to the OCM study, Canadians spend more than $30-billion per year on health care, in excess of $1,200 each, but even this large sum is 25% less than the comparable sum now being spent in the U.S. Table 1 summarizes the projected Canadian market for medical devices in 1987.

TABLE 1: 1987 CANADIAN MEDICAL-DEVICE MARKET (PROJECTED)

ITEM	Domestic market ($millions)	Imports Total ($millions)	Imports U.S. ($millions)
Cardiology equipment	41.3	29.5	26.3
Pulmonary equipment	18.1	12.9	11.6
Neurological equipment	7.4	5.3	4.5
Ophthalmological equipment	15.3	11.0	8.7
Pediatric equipment	9.0	6.5	5.2
Operating room equipment	67.2	48.4	39.0
General hospital equipment	150.0	90.0	76.5
Clinical lab equipment	71.7	55.2	49.7
Misc. health care products	3.4	2.4	1.9
Disposables	269.5	161.7	129.4
Orthopaedic and prosthetic	77.6	49.7	42.2
Architectural, transport and mobility	19.8	7.9	7.3
Physical and occupational therapy	16.8	5.0	4.5
Sensory aids	22.3	11.1	8.9
TOTAL:	819.3	518.1	432.6

Health-care expenditures are growing at 1.2% above the annual gross domestic product (GDP) increase in Canada (between 1961 and 1982); the comparable figure in the U.S. is 3%.

In response to rapid escalation in the cost of health-care delivery, both Canadian and U.S. systems are under pressure to contain further cost increases. Health-care systems will undergo a

dramatic transformation over the next two decades. Two major changes in patterns of delivery will be an increasing number of freestanding ambulatory-care centres and a growing market for home health-care goods and services.

Freestanding ambulatory-care centres provide specialized outpatient care at a substantially lower cost than acute-care facilities. Hearing, optical, dialysis, surgery, emergency-care and dental centres began appearing in the mid-1970's and have experienced rapid growth.

It is estimated that 30% to 40% of all surgical procedures in the U.S. could be performed on an outpatient basis in freestanding surgery centres.

Home health-care is a relatively new industry that has begun to grow significantly in recent years. One source says the market for home health-care products will reach U.S. $9.4-billion by 1990, up 65%. When nursing, technical and physical therapy services are added, the OCM report projects the total market for home health care at nearly U.S. $16-billion in 1990.

According to another study, the market for home diagnostics products will reach U.S. $875-million by 1990, an increase of 151% over the 1984 level. That report indicates the home diagnostics market in 1984 was segmented as follows:

Heart-related products	40%
Diabetes products	27%
Health-monitoring tests	18%
Disease diagnostics	15%

Many of these home diagnostics devices will use medical technology and microelectronics developed by, or in conjunction with, biomedical engineers. Home-care products already on the market include digital pulse meters and scales, electronic blood-pressure, heart-rate and glucose monitors, electronic thermometers, and transcutaneous electrical nerve stimulation (TENS) units.

Opportunities for the development of new medical technology will also exist in virtually every aspect of health care. New technology, particularly associated with rapid developments in microelectronics technology, will have a revolutionary impact on health care delivery

Numerous opportunities exist for companies based in British Columbia and elsewhere to develop new products which:

(a) represent advances in diagnostic, therapeutic and preventative health-care delivery;

(b) make it possible to deliver an increasing proportion of health care services in ambulatory clinics, private homes and nursing homes;

(c) are non-invasive, inexpensive and easy to use;

(d) do not require significant additional training or additions to medical/technical staff; and

(e) improve the productivity of medical/technical personnel.

Innovation and technological development, largely by biomedical engineers, will continue to serve as the engines of growth in a diversified medical devices industry.

In the past, innovation in health care was directed primarily towards improving the delivery of medicine. In the future there will be increasing emphasis on the development and diffusion of innovations which relocate the delivery of medicine or lower its cost.

The U.S. Department of Commerce reported that the medical electronics sector of the medical device industry in the U.S. consisted of 261 establishments in 1985. Two-thirds of these firms have fewer than 20 employees, providing an indication of the opportunities available to emerging firms with innovative products.

In 1985, the U.S. medical device and medical electronics sector of the medical device industry recorded a balance-of-trade surplus of U.S. $290-million, an increase of 12% over the previous year.

Over the 1976 to 1985 period the total value of shipments of medical devices incorporating electronics increased to U.S. $5.3-billion at an average annual rate of 17%. In 1972, medical electronics accounted for 11.6% of total shipments of medical devices. By 1983 this had increased to 31.6%.

In addition to products that will reduce our reliance on hospitals, there will be a strong demand for products developed by biomedical engineers that will improve the operational efficiency of hospitals. The impact that such new medical technology will have on health-care delivery includes the following.

Faster diagnosis. Using noninvasive techniques, new technology will allow for earlier diagnosis of disease, will increase the probability of early detection through regular monitoring, and will allow a greater number of tests to be performed in the same period.

More accurate diagnosis and therepy. Medical devices that incorporate new technology will increase the volume and quality of information physicians have about individual patients, allowing more accurate diagnosis and case-specific therapies.

Physicians will no longer have to rely on the shotgun approach of using a broad group of general therapeutic procedures designed to treat a number of illnesses.

Deinstitutionalized health-care delivery. Advances in medical telchnology by biomedical engineers will result in the development of smaller, less expensive, smarter, and easier-to-use medical devices. There will be an increase in the proportion of diagnosis and therapy done in alternative settings, including ambulatory-care centres and the home.

Development of less-invasive and noninvasive procedures. These new developments will cut the time required to administer specific diagnoses and therapies, reduce recovery time, and be generally less painful and traumatic. For example, CT scanning has dramatically slashed exploratory surgery for cranial, abdominal and mediastinal diagnoses. Before CT scanning, exploratory surgery was used in 33.9% of such diagnoses. By 1980, this figure was 16.5%.

Opportunities for applications of new technology in health care are very broad. Clearly, new industries based in British Columbia are unlikely to be able to participate on a world scale in every one of these emerging areas. However, there are a number of excellent existing and potential niches that could be identified, strengthened and exploited in British Columbia to establish a centre of excellence for the need-oriented development of new medical devices and related technology in conjunction with emerging and diversifying firms particularly in British

Columbia and elsewhere in Canada, for the world market. This is the strategy and focus of the UBC Biomedical Engineering Initiative.

APPENDIX II

FACULTY INVOLVED IN BIOMEDICAL ENGINEERING RESEARCH

DR. J. L. Bert, Professor	Department of Chemical Engineering
Dr. K. L. Pinder, Professor	Department of Chemical Engineering
Dr. J. R. Grace, Head	Deprtment of Chemical Engineering
Dr. M. P. Beddoes, Professor	Department of Electrical Engineering
Dr. C. A. Laszlo, Director	Department of Clinical Engineering
Professor	Department of Electrical Engineering
Dr. J. McEwen, Adjunct Professor	Department of Electrical Engineering
Dr. P. Lawrence, Professor	Department of Electrical Engineering
Dr. V. J. Modi, Professor	Department of Mechanical Engineering
Dr. L. D. Skarsgard, Professor	Department of Physics
Dr. B. Palcic, Assistant Professor	Department of Physics
Dr. G. Lam, Assistant Professor	Department of Physics
Dr. R. O. Kornelsen, Lecturer	Department of Physics
Dr. R. E. Durand, Honorary Professor	Department of Physics
Dr. P. L. Olive, Associate Professor	Department of Physics
Dr. K. A. Skov, Assistant Professor	Department of Physics
Dr. D. J. Chaplin, Assistant Professor	Department of Physics.

COURSES RELATED TO BIOMEDICAL ENGINEERING

Chemical Engineering

CHML 479 (Dr. J.L. Bert)
Chemical Engineering Aspects of Occupational Health Safety Relationship between current engineering practice and worker health and safety. Engineering analysis of industrial health and safety problems.

CHML 559 (Dr. N. Epstein)
Topics in Chemical Engineering: a discussion of some aspects of modern Chemical Engineering. Subject matter varies each year.

Clinical Engineering

APSC 550 (Dr. C. A. Laszlo)
Biomedical Measurements and Biomaterials: principles and technology of measuring temperature, displacement, motion, force, pressure, flow, ions, dissolved gases and bioelectric potentials in living organisms.

APSC 552 (Dr. C. A. Laszlo)
Clinical Engineering Seminar: Technology utilized in diagnosis, monitoring, therapy and rehabilitation.

APSC 554 (Drs. G. J. Eisler, R. W. Evans, C. Hershler, J. R. Heyworth, G. Klein, C. A. Laszlo, J. A. McEwen, K. D. Whitmore)
Directed Studies in Clinical Engineering: supervised work on several clinical engineering projects in local hospitals.

APSC 556 (Dr. C. A. Laszlo)
Clinical Engineering Practice: principles of management of clinical engineering practice, functions, organization and operation of hospital-based clinical and biomedical engineering departments.

Electrical Engineering

ELEC 473 (Dr. J. A. McEwen)
Systems Laboratory - Selected students undertake the development, design, implementation and evaluation of new or modified medical devices in an acute-care hospital environment.

ELEC 588 (Dr. M. P. Beddoes)
Biomedical Signals and Systems Analysis Modelling and analysis of biological control systems and prostheses.

ELEC 590 (Dr. P. D. Lawrence)
Speech Analysis and Synthesis: analysis and characterization of speech signals.

Mechanical Engineering

MECH 450 (Dr. B. Dunwoody)
Design I: Properties and selection of materials; stress concentration and fatigue; screws, fasteners and joints; mechanical springs; friction and wear. Prerequisite: MECH 341.

MECH 451 (Dr. B. Dunwoody)
Design II: Rolling and hydrodynamic bearings; spur, helical, bevel and worm gears; gear trains; shafts; clutches, brakes and couyplings; circuits; flexible machine elements. Prerequisite: MECH 450.

Metallurgical Engineering

METL 494 (Dr. E. Techtsoonian)
Composite Materials I: an introductory course dealing with fibres and resins; fabrication processes; properties of composites as laminae and laminates; designing with composites.

METL 594 (Dr. E. Techtsoonian)
Composite Materials II: mechanical behaviour of composite materials; tensile and compressive characteristics, toughness; fatigue; impact; environmental effects. Prerequisite: METL 494 Composite Materials I.

Physics

PHYS 305 (Dr. G. W. Hoffman)
Introduction to Biophysics: an introduction for physicists (assumed to have no background in biology) to the basics of molecular biology, followed by selected examples where insights from physical mathematics have helped solve important biological problems. Intended for students with 3rd or 4th year standing in physics. Not for credit for students in the Life Sciences.

PHYS 534 (Dr. R. O. Kornelsen)
Radiological Physics I: a systematic study of the principles involved in radiotherapy and of the techniques required for the application of these principles.

PHYS 535 (Dr. R. O. Kornelsen)
Radiological Physics II: a continuation of Physics 534, including an extension of the topics discussed in that course.

PHYS 536 (Dr. B. Palcic)
Advanced Radiation Biophysics: interactions of radiation with matter in living cells. Description of events following ionizing irradiation; cell survival as a function of dose; survival models. Students will be expected to present a seminar on a pre-selected topic, and participate in class discussions.

PHYS 405 (Dr. L. D. Skarsgard)
Radiation Biophysics: the physical and chemical interactions of ionizing and ultraviolet radiation and their biological effects at the cellular, tissue and whole animal levels. Topics in radiation dosimetry, radiation protection, and the treatment of malignant disease in humans will be included. Prerequisite: fourth year standing in Science, or permission of the head of the Department.

PHYS 406 (Dr. E. A. Evans)
Continuum Mechanics: mechanics of deformable bodies; equations of motion; stress and strain tensors. Basic concepts for solids and liquids with elements of nonlinear mechanics applicable to macromolecular structures such as polymeric materials and biological tissues. Prerequisites: PHYS 206 or 216 and MATH 316 or PHYS 312. Credit may be obtained for only one of PHYS 406 and GEOP 320.

APPENDIX III:

B.C. -BASED COMPANIES CURRENTLY MANUFACTURING AND/OR DEVELOPING MEDICAL DEVICES

ANDRONIC DEVICES LTD.
c/o VGH Research Institute
2660 Oak Street
Vancouver, B.C. V6H 3Z6
Telephone: 875-4288

Dr. Jim McEwen

Medical & Surgical Robotics; Automated Medical Devices

CHEAKAMUS HOLDINGS LTD.
3666 Yale Street
Vancouver, B.C. V5K 1C8
Telephone:

Dr. Vaclav Hyrman

Electroconvulsive therapy systems

C T F SYSTEMS INC.
Unit 15, 1750 McLean Avenue
Port Coquitlam, B.C. V3C 1M9
Telephone: 941-8561

Dr. Max Burbank

Medical equipment; SQUIDS

EKEG ELECTRONICS CO. LTD
Box 46199
Vancouver, B.C. V6R 4G5
Telephone: 685-7817

Dr. Peter Graystone

Medical telemetry & instruments

EPYTEC PROTOTYPES INC.
300-800 West Pender Street
Vancouver, B.C. V6C 2V8
Telephone: 681-0772

Dr. Boye Ahlborn

Prototypes of medical devices

FOSTER MANUFACTURING LTD.
107 Bowser Avenue
North Vancouver, B.C. V7P 3H1
Telephone: 986-5674

Hospital equipment, stainless steel products

GENERATION II ORTHOTICS INC.
128 West 8th Avenue
Vancouver, B.C. V5Y 1N2
Telephone: 879-8606

Lance Taylor

Orthopaedic braces & accessories

HODGSON ORTHOTICS LTD.
296 East 12th Avenue
Vancouver, B.C. V5T 2G9
Telephone: 872-4224

R. E. Parkinson

Orthopaedic devices

JOANCO MEDICAL ELECTRONICS LTD.
145 East 13th Street
Suite #704
North Vancouver, B.C. V7L 2L4
Telephone: 988-3020

Dr. B. Brown

Electronic & Hospital equipment
TENS stimulators

LABRON MOBILITY AIDS LTD.
3425 West 32nd Avenue
Vancouver, B.C. V6Y 1Y8
Telephone: 263-8482

K. A. Labron, President

Orthopaedic appliances

LLOYDS LEVERS
Box 71
Nass Camp, B.C. V0J 3J0
Telephone: 633-2435

Artificial Limbs

LOBEL & SON ORTHOPAEDIC
418 Columbia Street
New Westminster, B.C. V3L 3W9
Telephone: 533-8210

Orthopaedic equipment

MED-EX DIAGNOSTICS OF CANADA INC.
51 Leeder Avenue
Coquitlam, B.C. V3K 3V5
Telephone: 525-3685

Jim MacArthur

Automated health aids, hospital equipment

MITRAL MEDICAL OF CANADA LTD.
#1 - 11220 Voyageur Way
Richmond, B.C. V6X 3E1
Telephone: 270-7751

Biomedical equipment; cardiovascular supplies

PARAGON ORTHOTIC LABORATORY LTD.
1549 Broadmead Avenue
Victoria, B.C. V8P 2V1
Telephone: 721-1112

Dr. Glen Cornwall

Orthopaedic appliances

PENTLAND, J. A., LTD.
8239 Main Street
Vancouver, B.C. V5X 3L7
Telephone: 324-4011

J. A. Pentland, President

Orthopaedic devices

SCIENTEK HOSPITAL EQUIPMENT
Div. ABC Cassidy
2323 Quebec Street
Vancouver, B.C. V5T 3A3
Telephone: 879-6311

Hospital equipment

SHAPE TECHNOLOGIES INC.
304 - 2080 Maple Street
Vancouver, B.C. V6J 4P9
Telephone: 734-8605

Carl Saunders

CAD/CAM systems for the design of artificial limbs

TELEPRESENCE RESEARCH INC.
655 West 7th Avenue
Vancouver, B.C. V5Z 1B6
Telephone: 873-3300

Endoscopic vision systems

TIAC MANUFACTURING INC.
3080 Spring Street
Port Moody, B.C. V3H 1Z8
Telephone: 461-1626

Dr. H. Malm

Medical electronics

VIVITRO SYSTEMS INC.
c/o Cardiac Research Laboratory
Royal Jubilee Hospital
1900 Fort Street
Victoria, B.C. V8R 1J8
Telephone: 595-9578

Simulation and testing system for cardiac systems

WECO MANUFACTURING
P.O. Box 100
Kamloops, B.C. V2C 5K3
Telephone: 376-1261

Orthopaedic and rehabilitation appliances

WESTERN CLINICAL ENGINEERING LTD.
5259 Turquoise Drive
Richmond, B.C. V7C 4Z6
Telephone: 271-6288

Automated surgical tourniquets and related devices

WESTERN SCIENTIFIC SERVICES LTD.
11620 Horseshoe Way
Richmond, B.C. V7A 2V5
Telephone: 274-4111

Laboratory apparatus and supplies

APPENDIX IV:

ADDITIONAL B.C.-BASED FIRMS HAVING POTENTIAL INTEREST IN THE DEVELOPMENT/MANUFACTURE/FINANCING OF NEW MEDICAL DEVICES

ACCURATE RUBBER PRODUCTS LTD. — **Telephone: 274-9955**
12771 No. 5 Road
Richmond, B.C. V7A 4E9

Ian MacKenzie

ADVANCED LIGHT IMAGING CORP. — **Telephone: 433-3422**
#207 - 3700 Gilmore Way
Burnaby, B.C. V5G 4M1

ALAN CRAWFORD ASSOCIATES LTD. — **Telephone: 988-2195**
#410 - 212 Brooksbanks Avenue
North Vancouver, B.C. V7J 2C1

AMBREX INTERNATIONAL INC. — **Telephone: 464-8879**
125 - 3030 Lincoln Street
Coquitlam, B.C. V3B 6B4

Dr. R.K. Lomnes

AMMUNDSEN MEDICAL SUPPLY LTD. — **Telephone: 688-7611**
1062 Homer Street
Vancouver, B.C.

R. H. Ammundsen

ARMEX DISTRIBUTORS LTD. — **Telephone: 273-8358**
13120 Bathgate Place
Richmond, B.C. V6V 1Z2

John Hunter

B.C. CANCER FOUNDATION — **Telephone: 877-6010**
601 West 10th Avenue
Vancouver, B.C.
V5Z 1L3

B.C. MEDICAL EQUIPMENT LTD. — **Telephone: 876-4186**
2106 Main Street
Vancouver, B.C. V5T 3C5

B.C. RESOUCRES INVESTMENT CORPORATION **Telephone: 687-2600**
1176 West Georgia Street
Vancouver, B.C. V6E 4B9

M. G. McKibbin

BAKER HEALTHCARE PRODUCTS LTD. **Telephone: 324-7751**
Suite 214 - 8400 Main Street
Vancouver, B.C.
V5X 3L8

Bruce Opp

BC STEVENS COMPANY LIMITED **Telephone: 321-4121**
8868 Laurel Street
Vancouver, B.C. V6P 3V8

Steve Konstandien

BRENT SURGICAL LIMITED **Telephone: 324-1330**
282 S.W. Marine Drive
Vancouver, B.C. V5X 2R5

COLUMBIA PLASTICS LTD **Telephone: 879-2991**
2155 West 10th Avenue
Vancouver, B.C. V6K 2H7

Ian Howard

CREO ELECTRONICS CORP **Telephone: 437-6879**
110 - 3700 Gilmore Way
Burnaby, B.C. V5G 4M1

Dr. Ken Spencer

CUSTOM PLASTICS LTD. **Telephone: 736-9261**
Division of Fabriform Plastic Ltd.,
3818 Commercial Drive
Vancouver, B.C. V5N 4G2

Johan Wesson

DISCOVERY ENTERPRISES INC. **Telephone: 430-3533**
220 - 3700 Gilmore Way
Burnaby, B.C. V5G 4M1

Charles Kingston

EBCO INDUSTRIES LTD. **Telephone: 278-5578**
7851 Alderbridge Way
Richmond, B.C. V6X 2A4

Helmut Eppich

GRAPHIC CONTROLS CANADA LTD. — **Telephone: 277-0303**
Unit 12 - 11171 Horseshoe Way
Richmond, B.C. V7A 4S5

Paul Feduik

HOWMEDICA-MURPHY ASSOCIATES — **Telephone: 929-4510**
4033 Mt. Seymour Parkway
North Vancouver, B.C. V7G 1Z8

Terry Murphy

INSET LTD. — **Telephone: 261-3111**
Box 46654
Vancouver, B.C. V6R 4K8

Ron Green

JOBST DIVISION — **Telephone: 294-6229**
Zimmer Canada
Suite 206, 4585 Canada Way
Burnaby, B.C. V5G 1J9

David Mazzei

LEAR INDUSTRIAL DESIGN — **Telephone: 732-6581**
1535A West 3rd Avenue
Vancouver, B.C. V6J 1J9

Kevan Lear

3M CANADA INC. — **Telephone: 273-2211**
7100 River Road
Richmond, B.C. V6X 1X5

MACDONALD DETWILLER & ASSOCIATES — **Telephone: 278-3411**
3751 Shell Road
Richmond, B.C. V6X 2Z9

Dr. Dennis Connor

MEDICAL ELECTRONICS DIVISION — **Telephone: 291-0631**
Instrument Service Laboratories Ltd.
1375 Boundary Road South
Vancouver, B.C. V5K 4T9

MEDILOGIC LIMITED — **Telephone: 325-3282**
5755 Beresford Street
Burnaby, B.C. V5X 4S6

Rick Naylor

MOBILE DATA INTERNATIONAL INC. **Telephone: 277-1511**
11411 No. 5 Road
Richmond, B.C. V7A 4Z3

MOLI ENERGY LIMITED **Telephone: 465-7911**
20000 Stewart Crescent
Maple Ridge, B.C. V2X 9E7

R. LABORIE SURGICAL LTD. **Telephone: 684-3747**
Suite 2002, 1055 West Georgia Street
Vancouver, B.C. V6E 3P3

Michael Frith

ROBOTIC SYSTEMS INTERNATIONAL LTD. **Telephone: 656-0101**
9865 West Saanich Road
Sidney, B.C. V8L 3S1

Jack Wilson

SRC SOFTWARE RESEARCH CORP. **Telephone: 727-3744**
3939 Quadra Street
Victoria, B.C. V8X 1J5

Annette E. Wright

STARWEL INDUSTRIES LTD. **Telephone: 929-1045**
1185 Lima Road
North Vancouver, B.C. V7G 1G3

Robert W. Watler

TRIUMF **Telephone: 222-1047**
4004 Wesbrook Mall
Vancouver, B.C. V6T 2A3

Bill Cameron, Joel Rogers

VENTURES WEST TECHNOLOGIES **Telephone: 688-9495**
400 - 321 Water Street
Vancouver, B.C. V6B 1B8

James M. Fletcher

ZIMMER RUSSELL ASSOCIATES **Telephone: 294-6229**
Zimmer Canada
Suite 206, 4585 Canada Way
Burnaby, B.C. V5G 1J9

Bill Russell

APPENDIX V:

SELECTED B.C. AGENCIES WHICH COULD BENEFIT FROM A BIOMEDICAL ENGINEERING INITIATIVE

B.C. Children's Hospital

B.C. Institute of Technology

B.C. Cancer Foundation

G.F. Strong Rehabilitation Centre

Kelowna General Hospital

Royal Jubilee Hospital

St. Paul's Hospital

Shaughnessy Hospital

Simon Fraser University

Vancouver General Hospital

Victoria General Hospital

TRIUMF

UBC Health Sciences Centre Hospital

DRAFT

A PROPOSAL FOR THE ESTABLISHMENT OF

A JOINT SFU/BCIT/INDUSTRY
MANUFACTURING TECHNOLOGY CENTRE
FOR BRITISH COLUMBIA

DRAFT #3 FOR DISCUSSION

January 20, 1988

1 INTRODUCTION

British Columbia Industry faces increasingly aggressive foreign competition in both domestic and foreign markets. In order to compete successfully in the rapidly evolving and complex international trading environment - especially in a Free Trade environment - manufacturing industry must develop levels of performance at least comparable to those of its competitors.

Unfortunately there is sufficient evident to indicate that we are actually declining in terms of relative export performance and productivity improvement. Furthermore, import penetration by manufactured goods into the BC market place is projected to increase by at least 12% over the next 5 years as a direct result of Free Trade.

One of the ways to help combat this trend is through the adaption of new productivity-improving technologies such as CAD/CAM, automation, flexible manufacturing etc. These techniques are already widely used by our competitors and there are major commitments to government-supported programs aimed at facilitating implementation of these technologies.

BC industry needs help and support in this effort because most companies do not have the means to introduce changes that have a high capital cost and a high cost of implementation. In addition there is a shortage of trained people, a lack of knowledge of the technologies, and a very limited infrastructure to develop potential opportunities.

This document is a proposal for the establishment of a joint industry/SFU/BCIT Manufacturing Technology Centre for the express purpose of furthering the development and application of advanced manufacturing technologies through joint development projects.

2 THE NEED FOR A MANUFACTURING TECHNOLOGY CENTRE IN BC

Implementation of new technologies is crucial to economic advancement. It is the primary key to improvements in productivity, global competitiveness and, ultimately, employment. Rapid adoption of new technologies is therefore vitally important to future prosperity.

The efficacy with which BC enterprises, particularly those in our resource and manufacturing sectors, develop and adopt advanced technologies will largely determine the province's economic well-being.

While recent emphasis has been placed on applying technological advancements to Canada's primary industries and large scale manufacturers, the majority of BC 's burgeoning manufacturing sector consists of small to medium sized businesses.

In 1986, the manufacturing sector accounted for 14.1% of the Gross Domestic Product of the Province; it produced approximately $17 billion in factory shipments in 1985, which increased to approximately $20 billion in 1986. The manufacturing sector accounts for some 170,000 employed people in about 4,000 companies. The greater proportion, (92%), of these are in 3,500 companies with fewer than 100 employees - and it is these companies that need particular attention and support in becoming aware of new research and development and in implementing new technologies in their own organizations.

International competitiveness is a key factor for these companies, and Provincial statistics show that in 1986 less than $1 billion of the Province's $13 billion of exports were for manufactured goods. Real economic growth in BC will only occur when this proportion increases dramatically, and to do so, small and medium sized manufacturing businesses need to implement productivity-enhancing technologies to allow them to compete successfully.

Small manufacturers have unique needs and problems in applying technology to improve their production processes. These companies depend on exports, competitive advantage and flexibility in meeting customer demands. The addition of technology to their operations is a risky venture; one to be carefully evaluated prior to the commitment of resources. The fact is that no resource in the province exists (as opposed to Ontario, for example) to assist companies in their awareness, study and adoption of manufacturing technology.

Both Simon Fraser University and British Columbia Institute of Technology are centres of educational excellence within their respective domains.

They provide top quality education to prepare and upgrade or update individuals who are or will be employed by small manufacturers. They are an integral part of the high tech manufacturing infrastructure in BC. This education depends on the availability of systems for training as well as facilities for developing new designs and improvements on technology so that it can be used by British Columbia industry.

While these two institutions have the resources to produce exemplary graduates for such a task, what is also needed are the resources to "reach out" to the manufacturing sector in BC to assist them in introducing the process automation or manufacturing technologies so badly needed. This would include the adoption of computer-aided manufacturing, computer-aided design, computer numerical control, automated materials handling, automated inspection and quality control, etc.

Simon Fraser University School of Engineering Science and BCIT School of Engineering Technology and Trades are proposing the establishment of a Manufacturing Technology Centre to strengthen relationships already in place and provide an infrastructure for building new ones, through "hands on" demonstrations of various vendors' systems, concentrated training in new technologies, and joint research and development.

3 DESCRIPTION OF THE CENTRE

3.1 Mission Statement

The SFU/BCIT Manufacturing Technology Centre will provide manufacturing technology support services to aid and accelerate the development of BC's industrial and business community through increased application of technology, improvements in productivity and more effective use of material, capital, and human resources.

3.2 Goals

The primary goals of the Manufacturing Technology Centre will be to:

1. Assist small manufacturers to develop, study, test and adopt manufacturing technologies prior to full-scale implementation.

2. Create a greater awareness of manufacturing technology throughout BC industry, through effective technology transfer programs.

3. Pool scarce institutional resources to maximize economies of scale and realize the complementary nature of the two institutions.

4. Enhance the educational experiences of students at each institution through direct exposure to state-of-the-art technologies and practices and industry.

The Centre will provide impartial, objective, industry-oriented, hands-on, demonstration and applications services similar to those of a large manufacturing corporation resource group but not otherwise available to most of BC manufacturing industry.

To accomplish its mission it will make use of its faculty, staff and equipment from BCIT and SFU and it will become involved in a variety of activities, including:

- Outreach activities
- Training, Familiarization and Development
- Demonstration
- Technical Consulting
- Applied Research and Development
- Information Services

3.3 Key Assumptions for Success

The Plan presented here is based on the following assumptions:

- The Centre would be operated jointly by BCIT and SFU under an independent jointly-appointed industry Steering Board, reporting to the Boards of BCIT and SFU.

- Existing Robotics, Automation and CAD/CAM facilities on BCIT campus would be made available for the Centre consistent with current teaching commitments, and any procedures needed to allow use of equipment and faculty on assignment to the Centre would be put in place immediately.

- Establishment of the Centre would proceed on a phased basis, with the initial phase being identification of suitable industry partners and application areas.

- Priority to be given to establishing a flexible manufacturing cell for at least one specific application area in cooperation with local industry during the 1988/89 year.

- Any additional equipment required for the Centre to be acquired either by lease or on consignment from suppliers to minimize capital costs and allow for technological change.

- Activities to be scheduled to start in Fall 1988.

3.4 Measurement of Success

The ultimate measure of success of the Centre will be increased productivity of BC industry, the launch of new products, the consequent creation of new jobs and the number of valid applications of new technology that can be attributed to its efforts. However, it is unreliable to forecast new technology applications and productivity improvements will only be measurable over the longer term.

Some activity estimates have been made in the Plan to aid budgeting, but the principal measures of success will be the number of people from business and industry, the R & D industry, and other institutions who have constructive interactions with the Centre. These interactions consist of consulting projects, workshops, demonstrations, displays, outreach programs and information services.

A goal of recovering at least 90% of operating costs by year 5 is proposed. The ability of the Centre to recover operating costs will be a good measure of the value its clients will attribute to its work.

4 SERVICES TO BE OFFERED BY THE CENTRE

4.1 SCOPE OF THE CENTRE'S ACTIVITIES

4.1.1 Outreach

Outreach programs will be critical in stimulating interest in the services that the Centre could offer. It will take an aggressive approach to reaching out to industry, and will not assume that there is a latent demand for its services.

Some of the types of activities that would form part of the outreach would be:

- Mobile Laboratory; BCIT's mobile computer laboratory would be an excellent demonstration vehicle for a wide variety of technology applications.

- Trade Shows and Exhibitions and Public Speaking Events; The Centre would participate in at least two of the three or four major trade shows that take place locally annually in an effort to reach local manufacturers.

- Newsletter; The Centre would publish a periodical newsletter featuring case studies of work carried out by the Centre for clients, and technology awareness issues.

- Technology Awareness Seminars; The Centre would organize frequent seminars to generate awareness of new technologies new applications of technologies.

4.1.2 Training, Familiarization and Development

Through their existing continuing education programs , both BCIT and SFU already offer a wide range of training in many fields.

When industry needs are currently being met by these services, the Centre will not duplicate the service but will develop a complementary role by referring enquiries to the most appropriate resource. However, the Centre can fulfil the important task of assisting companies and organizations to identify special training needs, encouraging and facilitating the modification and development of existing programs and courses.

Where there are gaps in available training, especially in one-off situations, the Centre will develop short workshops typically 2 to 5 days long on contract or for a wider audience.

One particular training method which would be encouraged is that of actively recruiting secondments and contract employment with people from BC industry who would be trained at the Centre for a 1-month to 12-month period in a role beneficial to both SFU, BCIT and the sponsoring employer.

4.1.3 Demonstration

One important service proposed for the Centre is demonstration of new technologies and their application to a particular client's operations. Particular areas where this service will be important are:

- CAD/CAM; demonstration of capabilities and actual demonstrations using a client's specific applications on mini or microcomputer based systems.

- Robotics and Automation; use and demonstration of robots for spot welding, arc welding, spray painting, assembly, machine loading and unloading and general material handling.

- Computer Applications; open access workshops, and training and advisory sessions to help small businesses apply Information Technology. Equipped to do this mainly by systems provided by manufacturers and suppliers on consignment, the Centre would have a representative selection of current microcomputers and software.

4.1.4 Technical Consulting/Applied Research and Development

Technical consulting and research and development would be carried out for companies by the Centre under a Code of Practice that avoided overt competition with the private sector.

Nevertheless, the Centre would embark on projects which might well be capable of being handled by the private sector. The rationale for this is that the clientele of the Centre will primarily be small and medium businesses who otherwise would not be likely to engage a private sector consultant either because of cost or fear of not receiving impartial and unbiased recommendations.

In similar Centres established elsewhere, fears of problems caused by competition with the private sector have proven groundless, and the general growth of business occurring as a result of technology transfer and improved business methods has actually provided private sector consultants with more business than they would otherwise have had.

The Centre's consulting and applied research activities would be restricted to those in which there is an emphasis on providing solutions to immediate or short-term problems to manufacturing problems.

4.1.5 Information Services

The Centre would act as a complete source of current information on manufacturing technology in conjunction with the SFU and BCIT Libraries. It would maintain links to other libraries and other research and assistance centres so that clients could have access to a wide range of information services and data banks.

Client companies would be able to contract for reference lists, annotated bibliographies, state-of-the-art reviews, surveys of patent specifications, and a "current awareness service" alerting them to publication of technical developments falling within an agreed profile of interests.

4.2 USERS OF THE CENTRE

The large manufacturing companies generally have both financial and staff resources to engage in innovation and research and development and as a result are unlikely to be major clients of the Centre.

Small companies are at the other extreme and are expected to be the prime target group for the Centre. Manufacturing companies with fewer than 30 employees often have a low incidence of computers even in administrative functions, but with the growth of user-friendly software especially in areas such as CAD/CAM, this is changing.

Smaller companies will provide the major source of new jobs and wealth in the next decade, and will be candidates for the full range of the services proposed for the Centre. Because the companies are small, they are often very receptive to new ideas, it is easier to identify decision makers, and consequently they are somewhat easier to deal with than either the large companies or the medium-sized ones.

Many companies and organizations in the 50-250 employees size range have adopted computers to the same extent as large companies, and often have the expertise to deal with problems posed by new technology within their own resources. However, many of these companies are often plagued by either old-fashioned methodologies or skepticism of the cost-effectiveness of new ones. It is as important to reach the senior decision makers in these companies as it is to reach those responsible for production or engineering applications.

4.3 RELATIONSHIPS WITH OTHER ORGANIZATIONS

As a focus for encouraging manufacturing technology transfer to BC industry, the Centre will provide a coordinating link between the SFU and BCIT communities, the business and industrial

community, government, research organizations, consultants, other educational establishments and industrial and trade organizations.

The Centre will not duplicate existing resources at SFU or BCIT, or compete with other organizations engaged in similar work. It will work with the existing departments and technologies within SFU and BCIT, utilizing their resources as available through secondment and on contract. It will work with organizations such as BC Research, Discovery Foundation, and the other universities and colleges to fulfil its mandate.

The Centre's activities will complement those offered by private consulting firms. Such firms generally undertake work for the sole benefit of a single client, usually within the limitations of current technology and proven techniques. The Centre's activities will be more geared towards undertaking work which will disseminate knowledge, techniques and procedures, avoiding conflict with private consultants. Where possible or desirable, users of the Centre will be directed impartially to organizations and specialists who can provide the necessary resouces and capabilities. In addition, the Centre may act as a clinic in which the consultant may represent his client and use facilities and services.

5 ORGANIZATION PLAN

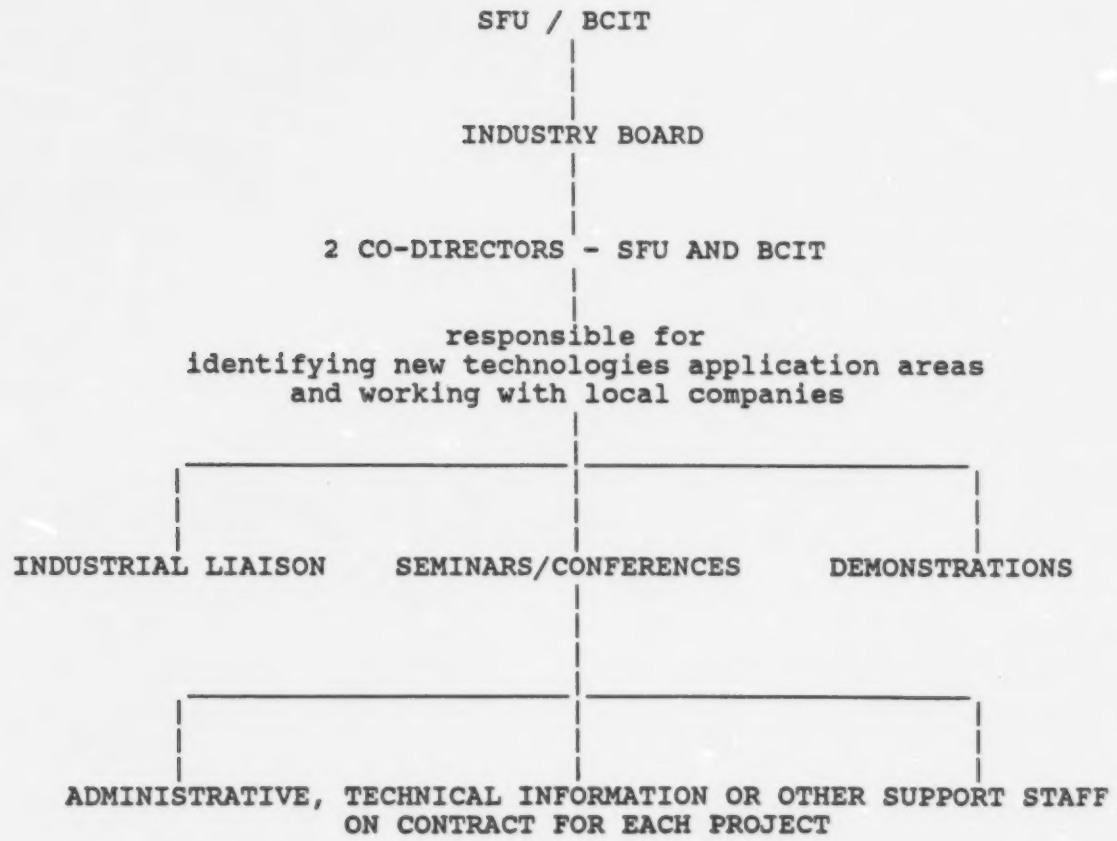
5.1 PROPOSED STRUCTURE

The Centre would have separate components reflecting the educational focus of each institution. Joint research and teaching activities between SFU and BCIT faculty would be encouraged, as would the sharing of facilities.

The Centre would be jointly managed by two Co-Directors, one from each institution. These would work with a Steering Board established jointly by SFU/BCIT and industry.

Any staffing would be on a short-term contract basis made on the basis of committed project workload, possibly with staff secondment from within SFU or BCIT or from companies in order to handle project work.

The proposed structure is shown below:



5.2 LOCATION AND FACILITIES

Because there are extensive manufacturing equipment and systems already in place, it makes sense to locate the Centre at BCIT. As research and development in manufacturing technologies at SFU become established, facilities in the new Applied Sciences Building (currently under construction) could be used for research projects.

6 START-UP PRIORITIES

Between January 1988 and March 31, 1987 the Centre should address itself to the following priorities:

- Appointment of Centre Co-Directors.
- Securing an indication of the level of industry support.
- Securing an indication of the level of government support.
- Appointment of Industry Steering Board .
- Establishing a Code of Practice and securing agreement within SFU, BCIT and with the external community for this.
- Identifying at least two interested industry partners.
- Carrying out a feasibility study on the establishment of a Flexible Manufacturing Cell in a particular application area.
- Commencing the process of obtaining funding for establishing the Cell.

7 FINANCIAL PLAN

This portion of the report is still in the process of discussion and preparation.

DRAFT

PROPOSAL FOR AN

AUTOMATION AND ROBOTICS LABORATORY(ARL)

Prepared for: The British Columbia Science Council

Prepared by: Dr. Dale B. Cherchas

Professor, Department of Mechanical Engineering

University of British Columbia

Dr. Peter D. Lawrence

Professor, Department of Electrical Engineering

University of British Columbia

March 8, 1988

SUMMARY

A proposal is made to solicit funding for a laboratory in which to perform joint industry–University research and development projects in the area of robotics and automation technology. The projects will be chosen to improve our competitiveness in the resource industries and facilitate a transition to a more diversified manufacturing and knowledge based, as well as resource based, economy.

The theme of the laboratory will be to develop robotics and automation devices capable of performing certain categories of tasks of importance to the resource industries. These tasks are primarily materials handling and manipulation tasks. Examples of the industrial application of telerobotics technology are in: the control of subsea manipulators; control of construction machines such as excavators and cranes; control of public utilities' equipment such as machines for distribution line maintenance; and finally in the mining industries for the remote control of mining machines. As well, specific classes of industrial tasks of importance to secondary manufacturing in B.C. will be addressed. These are assembly and inspection and certain processing tasks including arc welding and machining operations.

The estimated funding requirements are: total recurring costs of $865,100 per year, total startup equipment costs of $670,000, and total space costs of $1,819,000. Other sources may be providing funding for the required space as part of the larger project at UBC of establishing a permanent CICSR building. The laboratory would be located on the University of British Columbia campus as part of the Centre for Integrated Computer Systems Research (CICSR) and would have office and laboratory space for industry research staff. The laboratory will generate economic benefits for B.C. and Canada through productivity and safety improvements in resource and other industries, robotics and automation technology sales and new opportunities for economic development through automation and robotics technologies.

TABLE OF CONTENTS

SECTION	TITLE	PAGE
1.0	INTRODUCTION	-1-
1.1	Rationale and statement of need	-1-
1.2	Laboratory objectives	-1-
2.0	LABORATORY ACTIVITIES & OPERATION	-2-
2.1	Joint industry/university research and development projects	-2-
2.2	Industrial education	-2-
2.3	New Technology awareness and needs identification	-2-
2.4	Knowledge dissemination	-3-
2.5	Management	-3-
3.0	LABORATORY FACILITIES & STAFFING REQUIREMENTS	-4-
3.1	Laboratory and shop space	-4-
3.2	Office, meeting room, library space	-4-
3.3	Staff	-4-
3.4	Equipment	-5-
4.0	LABORATORY ECONOMIC BENEFITS	-6-
4.1	Productivity and Safety, improvement in resource and other industries	-6-
4.2	Robotics and automation technology sales	-8-
4.3	New opportunities for economic development through robotics and automation technology	-8-
5.0	CURRENTLY EXISTING FACILITIES & ACTIVITIES	-9-
5.1	University of British Columbia	-9-

5.2	Simon Fraser University University of Victoria	-10-
5.3	Advanced Systems Institute, Canadian Institute for Advanced Research	-10-
5.4	Industry	-10-
6.0	LABORATORY FUNDING REQUIREMENTS	-12-
7.0	LABORATORY LOCATION	-14-
8.0	CONCLUSIONS	-15-

1.0 INTRODUCTION

1.1 Rationale and Statement of Need

In order to maintain and enhance our standard of living, it is necessary for B.C. and Canada to develop and use advanced technology tools in automation and robotics to establish and ensure our competitiveness as an industrialized nation. These tools must be developed and used specifically for the resource industries as our major economic base as well as for the necessary and continuing transition from a resource based economy to a more diversified manufacturing, knowledge and resource based economy. Government has a major role to play in this transition and government funding must be used effectively to combine the ideas, expertise and skills of industry researchers and University faculty members. An effective way to enable B.C. and Canadian industry to participate in and make optimum use of automation and robotics technology is through the establishment and operation of a joint industry University research laboratory. The laboratory is the best way to perform focussed industrial research with university research staff ideas and expertise and see rapid and direct transfer of results to B.C. and Canadian industry

1.2 Laboratory objectives

The main objectives of the laboratory are to:

a) perform joint industry-University research projects to effectively develop, transfer and implement robotics and automation technology for B.C. and Canadian industry. Research is necessary to develop technology that is particularly relevant to B.C. industries.

b) promote the orientation and education of engineers in industry in the robotics and automation technology area.

2.0 LABORATORY ACTIVITIES AND OPERATION

2.1 Joint Industry University research and development projects

This will be the major activity of the laboratory and will see industrial research staff, university faculty and students working together in a shared laboratory. The industry research staff will have offices in the laboratory, to ensure direct daily contact with university staff. The projects will be chosen particularly for economic benefits in the resource industries and for the most productive transition to a more diversified manufacturing, knowledge and resource based economy, through the direct technology transfer process occurring in the laboratory projects. The joint research projects will include such areas as sensors and machine vision systems, manipulator force and position control, computer assisted teleoperation, automatic task and trajectory planning, etc. The projects will focus on the generic tasks of materials handling and manipulation for the resource industries and robotic assembly and inspection, arc welding and robotic machining operations for the secondary manufacturing sector.

2.2 Industrial education

In most instances the salaries of industry researchers working on site in the laboratory will be paid by industry. However, in those instances where this is not feasible or where industry staff may wish to simultaneously pursue an advanced degree but require sufficient income to meet their established financial responsibilities, an industrial fellowship program will be implemented. As well, short courses and seminars will be given on a regular basis to provide immediate and contemporary education in automation and robotics technology.,

2.3 New Technology Awareness and Needs Identification

This important activity will entail continuing review of relevant technology developments and the establishment of a library of supporting documentation. As well,

laboratory staff will continue an active examination of current industries and possible new industries to identify the needs for appropriate and transition technology. This activity should be carried out in a university setting to ensure that university faculty are continually aware of problems requiring research level solutions.

2.4 Knowledge Dissemination

New knowledge and results will be disseminated, where appropriate, by means of seminars, conferences and laboratory reports. As well, a yearly progress and research summary report for the laboratory will be prepared. Industrial proprietary results will be respected.

2.5 Management

In general, the laboratory will be operated on a project oriented basis, however, the basic operation of the laboratory will be managed by an executive director together with a joint steering committee of government, industry and University representatives.

3.0 LABORATORY FACILITIES AND STAFFING REQUIREMENTS

3.1 Laboratory and Shop space

Laboratory space and services will be required for large scale manipulator and teleoperator projects as well as for smaller industrial robotics projects. Laboratory space and services will also be required for full scale industrial automation projects. Supporting project area workbenches and Mechanical and Electrical shop space will be required.

3.2 Office, Meeting Room, Library space

A major and critical requirement is office space for on site industry professional research staff. As well, offices will be required for permanent laboratory research engineers and technicians and management and clerical staff.

Project meetings and knowledge dissemination will require sufficient meeting rooms and facilities. Space for a permanent, in laboratory, library documenting current developments in automation and robotics technology, and relevant information on user industries will be needed to meet the objectives of the laboratory.

3.3 Staff

The staffing requirements for the laboratory fall into the following categories:

a) permanent laboratory research engineers

b) permanent laboratory technicians

c) permanent laboratory management staff

d) permanent laboratory clerical staff

The research engineers and technicians are required to ensure the continuous and dedicated manpower needed to allow the laboratory to maintain a lead in automation and robotics research. Management (see Section 2.5) and clerical staff are needed to operate the necessary financial and office activities of the laboratory.

It is important to note that the university will be providing research faculty and, where appropriate, graduate students so funding is not required for these personnel.

3.4 Equipment

The permanent equipment requirements for the laboratory are as follows, noting that additional equipment for specific projects will be procured as needed:

a) basic complement of instrumentation and test equipment

b) one mainframe or supermini computer

c) a number of microcomputers

d) basic library of utility software

e) workbench and shop equipment and machine tools

f) office furniture and equipment

4.0 LABORATORY ECONOMIC BENEFITS

There are three major ways by which the establishment and operation of the laboratory will yield significant economic benefits.

4.1 Productivity and safety improvement in resource and other industries

It has been shown that major economic returns can be realized from small percentage improvements in productivity, unit cost reduction and waste reduction in high volume industries such as forestry, pulp and paper, fishing, mining, agriculture and associated manufacturing industries.

For over 30 years extraction and processing of natural resources has been the major basis for growth of the B.C. economy. This development has also resulted in subsequent manufacturing and knowledge-based industries and, as well, the economy has become increasingly diversified. Continued development of the economy depends on both management and development of natural resources and on investment in manufacturing and goods-producing and service industries. Several tables from the Financial and Economic Review, 47th Edition, September 1987, Ministry of Finance and Corporate Relations, Province of British Columbia. are given below for the B.C. economy.

Real Gross Domestic Product (1971 dollars)[1]

Sector	1979	Per Cent of Total	1985	Per Cent of Total	1986	Per Cent of Total
	($ millions)		($ millions)		($ millions)	
Agriculture	155	1.3	215	1.4	215	1.4
Forestry	340	2.8	380	2.6	379	2.5
Fishing and trapping	39	0.3	65	0.4	53	0.3
Mining	337	2.8	404	2.7	404	2.7
Manufacturing	2,034	16.8	2,078	14.1	2,142	14.1
Construction	857	7.1	931	6.3	933	6.2
Utilities	455	3.8	634	4.3	616	4.1
Total goods	4,217	34.9	4,697	31.8	4,742	31.3
Transportation, communication and storage	1,545	12.8	1,862	12.6	1,961	12.9
Wholesale and retail trade	1,841	13.6	1,912	13.0	1,999	13.0
Finance, insurance and real estate	1,455	12.0	2,438	16.5	2,535	16.7
Community, business and personal services	2,371	19.6	2,908	19.7	3,010	19.9
Public administration and defence	855	7.1	935	6.4	944	6.2
Total services	7,867	65.1	10,055	68.2	10,419	68.7
Total goods and services	12,084	100.0	14,752	100.0	15,161	100.0
Unallocated residual[2]	(477)		(50)		(49)	
Gross domestic product	11,607		14,702		15,112	

[1] GDP is shown at factor cost which is less than GDP at market prices by the amount of indirect taxes less subsidies.
[2] Unallocated residual arises due to the use of different deflators for each sector and for the components of GDP.
Note: Segmentation error.
Source: British Columbia Economic Accounts and Ministry of Finance and Corporate Relations estimates.

Value of Manufacturing Shipments

Industry	1984	Per Cent of Total Manufacturing	1985	Per Cent of Total Manufacturing	1986	Per Cent of Total Manufacturing	Change 1985–1986
	($ millions)		($ millions)		($ millions)		(per cent)
Wood	4,542	25.6	5,162	26.9	5,510	26.7	6.7
Paper and allied products	3,131	17.7	3,403	17.8	3,929	19.0	15.5
Food	2,250	12.7	2,369	12.4	2,740	13.3	15.7
Refined petroleum and coal products	2,200	12.4	2,416	12.6	2,179	10.6	−9.8
Fabricated metal products	790	4.5	818	4.3	928	4.5	13.4
Primary metals	844	4.8	806	4.2	788	3.8	−2.2
Transportation equipment	683	3.9	743	3.9	785	3.8	5.7
Chemicals and chemical products	577	3.2	581	3.0	608	2.9	4.6
Machinery (except electrical machinery)	368	2.1	394	2.0	451	2.2	14.5
Non-metallic mineral products	450	2.5	453	2.4	474	2.3	4.6
Electrical and electronic products	216	1.2	214	1.1	241	1.2	12.6
Clothing	135	0.8	149	0.8	168	0.8	12.8
Furniture and fixtures	104	0.6	109	0.6	132	0.6	21.1
Other	1,420	8.0	1,540	8.0	1,706	8.3	10.8
Total	17,710	100.0	19,157	100.0	20,639	100.0	7.7

Source: Statistics Canada, Catalogue 31-001.
Note: Based on the 1980 Standard Industrial Classification.

These tables show that, not withstanding the fact that the service sector accounted for 68.7% of the B.C. Gross Domestic Product (GDP), in the goods sector, manufacturing was the major source at 14.1% of the GDP. However approximately 75% of manufacturing in B.C. is related to resource processing, mainly in the forest products industry. Secondary manufacturing did increase in 1986, mainly in metal fabricating, furniture and fixtures and clothing by 10% to $5.5 billion. It is interesting to note that in Ontario manufacturing accounts for 29% of that province's GDP with the manufacture of

transportation equipment, food processing and fabricated metal products the top three, each producing approximately $3.5 billion annually. For Canada, manufacturing accounts for 21% of the Gross National Product (GNP) while in Japan it accounts for 39% of the GNP of that country.

As is very clear in the world market today, the production and export of manufactured goods can be a major source of income. However, advanced technology must be appropriately used to allow B.C. and Canada to maintain and expand this activity profitably.

4.2 Robotics and Automation Technology Sales

There is a growing market worldwide for automation and robotics technology. The proposed laboratory research activities will allow B.C. and Canadian industry to compete in this market.

4.3 New opportunities for Economic Development through Robotics and Automation Technology

Automation and Robotics technology will facilitate new endeavors and economic activity. Examples are: the use of marine robots for subsea mineral exploration and retrieval, marine farms, construction and repair of structures or possibly sovereignty surveillance.

5.0 CURRENTLY EXISTING FACILITIES AND ACTIVITIES

5.1 University of British Columbia

U.B.C. has the following relevant facilities and activities

a) Department of Mechanical Engineering – the Department has 19 current and 5 soon to be hired Faculty with 9 of this total in automation and robotics; the Department held $431,000 in grants and contracts in 1985/86 for computer integrated systems research and operates a small Computer Aided Manufacturing and Robotics laboratory (CAMROL) involved in basic and applied contract and grant research. A recent contract has been the development of an automatic off line programming system for welding robots. CAMROL publishes a report series.

b) Department of Electrical Engineering – the Department has 25 current and 3 soon to be hired Faculty with 7 of this total in robotics and automation; the Department held $816,000 in grants and contracts in 1985/86 for computer integrated systems research and has a small Joint Robotics and Teleoperator Laboratory (JRTL) successfully performing grant and contract funded research in teleoperator and manipulator technology. A current major project with McMillan Bloedel is the development of computer control for forestry manipulators.

c) Department of Computer Science – the Department has 17 current and 3 soon to be hired Faculty, 5 of this total in artificial intelligence and machine vision; the Department held $1,193,270 in 1985/86 for computer integrated systems research; the Department has the Laboratory for Computational Vision.

d) Centre for Integrated Computer Systems Research (CICSR)

This recently funded academic centre facilitates joint Faculty activities between the Departments of Electrical Engineering, Computer Science and Mechanical Engineering in computer related areas and has permanent recurring funding, primarily for faculty positions, starting at $1 million per year and rising in 3 years to $2 million per year. The proposed laboratory will be part of the CICSR facility.

5.2 Simon Fraser University, University of Victoria

Simon Fraser University has a Faculty of Engineering Science with one Faculty member in robotics, a Department of Computer Science and a Centre for System Science (CSS) similar to CICSR at U.B.C.

The University of Victoria has a Department of Electrical Engineering with several Faculty members in robotics and a Department of Mechanical Engineering (currently being formed) that will have some Faculty members in robotics.

5.3 Advanced Systems Institute, Canadian Institute for Advanced Research

The Advanced Systems Foundation and Institute is a B.C. based institute recently formed to foster research and scholarship in advanced systems through fellowships, scholarships and knowledge dissemination funding.

The Canadian Institute for Advanced Research is a Toronto based organization with a current network of researchers in artificial intelligence, one node of which is in B.C. The CIAR may be interested in forming a robotics node in B.C.

5.4 Industry

There are a number of robotics and automation companies in B.C. and Canada, for example:

- Robotics Systems International (Sidney, B.C.)
- International Submarine Engineering (Port Moody, B.C.)
- Andronic Devices (Vancouver, B.C.)
- McDonald Dettwiler (B.C.)
- Horizon Robotic Systems (Saskatoon, Sask.)
- Bata Engineering (Batawa, Ont.)
- Clay Mill Technical Systems (Windsor, Ont.)
- Diffracto (Windsor, Ont.)
- Spar Aerospace (Toronto, Ont.)
- Servo-Robot (Boucherville, Que.)

and a significant number of resource and secondary manufacturing industries.

6.0 LABORATORY FUNDING REQUIREMENTS

The funding requirements for the laboratory are in the categories below. University faculty are of course funded from the university budget and hence the laboratory funding will be adding to a major prior commitment in the automation and robotics area.

a) Staff

Position	No.	Salary($)	Total($)
Executive Director	1	60,000	60,000
Research Engineer	2	40,000	80,000
Technologists	2	32,000	64,000
Secretary/receptionist	2	20,000	40,000
Librarian	1	30,000	30,000
			$274,000
benefits @ 15%			41,100
		TOTAL	$315,100/yr

b) General office and Library supplies and operating expenses $20,000/yr

c) Space

USE	UNITS (sq. ft.)	No. of Units	Total (sq. ft)
Labs, R & D	650	3	1950
Labs, R & D	2000	2	4000
Mech. Shop	500	1	500
Elec. Shop	500	1	500
Stores	250	1	250
Offices	150	15	2250
Secretary/reception	250	1	250
Seminar/meeting room	250	2	500
Library	500	1	500
		TOTAL	10700 (sq. ft.)
New (excluding land) Building or Lab	10,700 x $170/sq.ft.		$1,819,000

d) Project funding

3 projects @ $100,000/yr	
equipment & expenses	$300,000/yr

e) Industrial fellowships, student support

3 industrial fellowships x $40,000	$120,000
4 grad student stipends x $20,000	$ 80,000
(additional students)	$200,000
benefits @ 15%	$ 30,000
Total	$230,000

f) Equipment

- basic instrumentation and test equipment	$ 30,000
- mainframe or supermini computer	$200,000
- 4 microcomputers	$ 80,000
- basic library of utility software	$ 40,000
- workbench and shop equipment and machine tools	$300,000
- office furniture and equipment	$ 20,000
	$670,000

Total recurring costs	$ 865,100/yr
Total startup equipment	$ 670,000
Total space costs	$1,819,000 *

* Other sources may be providing funding for the required space as part of the larger project at UBC of establishing a permanent CICSR building.

7.0 LABORATORY LOCATION

To allow practical and effective use of university faculty, the laboratory should be located on a university campus. The University of British Columbia has a significant number of faculty and major current activities in automation and robotics and would enthusiastically accommodate the laboratory. It is suggested that the main laboratory be located at the University of British Columbia and collaboration be maintained with Simon Fraser University and the University of Victoria. The laboratory will be part of the CICSR facility at the University of British Columbia.

8.0 CONCLUSIONS

The proposed laboratory will allow effective use of government funding to directly support industrial research and development in automation and robotics and simultaneously employ the research ideas, expertise and skills of university faculty.

The results of the laboratory operation will enable B.C. and Canadian industry to make optimum use of automation and robotics technology and will generate significant economic benefits.

SUMMARY OF RECOMMENDATIONS FROM ALL SECTORS

AGRICULTURE AND FOOD PROCESSING

RECOMMENDATIONS (CONT'D.)

- FUNDING FOR SECONDARY MANUFACTURE, FOOD PROCESSING
- RESEARCH ORGANIZATIONS STAFFING AND EQUIPMENT
- GENERAL AWARENESS
- TECHNOLOGY TRANSFER

AQUATIC RESOURCES

$750M INDUSTRY

AQUACULTURE - HIGH GROWTH
- SCIENCE ISSUES

RECOMMENDATIONS

- WATER QUALITY
  - SPECIFIC CONTAMINANTS
  - AQUACULTURE
- AQUATIC INSTRUMENTS AND DEVICES
  - INTERFACE WITH SECTOR
  - GROWTH AREA
- FISH HARVESTING
  - GOVERNMENT AND SOCIAL POLICIES
  - IMPROVEMENTS POSSIBLE
  - SHIP/SHORE COMMUNICATION

AQUATIC RESOURCES

RECOMMENDATIONS (CONT'D.)

- FISH PROCESSING
  - NEW PRODUCTS
  - BY-PRODUCTS
  - QUALITY
  - PACKAGING
- AQUACULTURE
  - INTERFACE WITH BIOTECHNOLOGY
    - DISEASE CONTROL
    - NUTRITION
    - GENETICS
    - WASTE MANAGEMENT
  - NETWORK OF EXCELLENCE

BIOTECHNOLOGY

EMERGING INDUSTRY - $12M

IMPACTS ON MANY SECTORS - FORESTS
- AGRICULTURE
- AQUACULTURE
- HEALTH
- WASTE MANAGEMENT
- MINING

NEED FOR STRATEGIC PLANNING, CO-ORDINATION

RECOMMENDATIONS

- FOCUS ON
  - DISEASE CONTROL
  - GENETIC IMPROVEMENT
  - WASTE MANAGEMENT

- STRATEGIC PLANNING - USE OF EXISTING COMMITTEE

- LONG TERM COMMITMENT OF FUNDING

- RAISE FUNDING FROM $10M TO $30M - 5-10 YEARS

BIOTECHNOLOGY

RECOMMENDATIONS (CONT'D.)

- STRATEGIC RESEARCH, TRAINING, SCHOLARSHIPS
- INDUSTRY/UNIVERSITIES INTERACTION
- REVIEW FACILITIES NEEDS AND CO-ORDINATION

ENERGY

MAJOR RESOURCE OF PROVINCE

DEPENDENCE OF OTHER RESOURCE SECTORS

OIL - IMPORT TO B.C.

NATURAL GAS SURPLUS

RECOMMENDATIONS

- OIL & GAS
  - DEVELOP UNDERSEA ROBOTICS
  - PREPARE FOR SWITCH AWAY FROM OIL
  - NATURAL GAS DIESEL ENGINE CONVERSION
- COAL
  - DEVELOP CAPABILITY TO ANALYZE COALS
  - BENEFICIATION & TRANSPORTATION
  - ALTERNATIVE USES

ENERGY

RECOMMENDATIONS (CONT'D.)

- WOOD RESIDUE AND BIOMASS
  - CONTINUE DEVELOPMENTS - METHANOL, ETHANOL
- OTHERS
  - HYDROGEN
  - FUEL CELL

SCIENCE & TECHNOLOGY ENERGY FOCUS

- CENTRE FOR ENERGY STUDIES
- BUILD EXPERTISE
- UNDERTAKE TESTS
- NATURAL GAS
- LONGER TERM ITEMS

FORESTS AND FOREST PRODUCTS

GROWTH AREA

MOVING TO VALUE ADDED PRODUCTS

RESOURCE DIMINISHING AND MORE EXPENSIVE

WORLD-WIDE COMPETITION

DEPENDENCE ON SCIENCE & TECHNOLOGY

ADVANCED MACHINERY AND SYSTEMS

PEOPLE NEEDS

RECOMMENDATIONS

- OVERALL CO-ORDINATION FOR SCIENCE AND TECHNOLOGY
- ADD VALUE
- IMPROVE PRODUCTION FOR RESOURCE

FORESTS AND FOREST PRODUCTS

RECOMMENDATIONS (CONT'D.)

- RAISE TECHNOLOGICAL AWARENESS AND COMPETENCE
  - RESEARCHERS
  - 'RECEPTORS'
- TECHNOLOGY TRANSFER
- USE OF ADVANCED SYSTEMS, TECHNOLOGIES AND MACHINERY

INFORMATION TECHNOLOGY

$1 BILLION INDUSTRY

11,500 PEOPLE

25%-50% ANNUAL GROWTH

RESOURCE INDUSTRIES/INFORMATION TECHNOLOGY

PEOPLE NEEDS

CO-ORDINATED ACTIONS

RECOMMENDATIONS

- ENHANCE RESOURCE INDUSTRIES BY ENHANCING THE INFORMATION TECHNOLOGY INDUSTRIES
- COMMIT TO INFORMATION TECHNOLOGY
- MARKETING, MANAGEMENT, TECHNICAL PEOPLE
- CO-ORDINATION AND PLANNING ROLE
- INFRASTRUCTURE AND SUPPORT

MANUFACTURING

IMPORTANCE TO PROVINCE

4,000 COMPANIES - 40 LARGE

LACK OF TRAINING

DIFFICULTIES OF LOCATING PARTNERS

TECHNOLOGY TRANSFER - SMALL COMPANIES

RECOMMENDATIONS

- STRATEGIC PLAN - 'CHAMPION'
- BIOMEDICAL DEVICES
- EDUCATION AND TRAINING
- TECHNOLOGY CENTRE
- RESOURCE INDUSTRIES - ROBOTICS
- NETWORKING
- CAD/CAM
- FUNDING

MINING, MINERALS, METALS

NEEDS

- INDUSTRY INVOLVEMENT
- NATIONAL CO-ORDINATION
- FOCUS ON R&D
- RAISING AWARENESS

RECOMMENDATIONS

- R&D CO-ORDINATOR FOCUSSED ON B.C. NEEDS, NATIONAL INTERFACE

- INDUSTRY CHAIRS - ADVANCED MATERIALS

- CENTRES OF EXCELLENCE:

  - ADVANCED MATERIALS
  - INDUSTRIAL MINERALS
  - GEOLOGICAL EXPLORATION
  - RARE & PRECIOUS METALS

EMERGING THEMES

- BUILD ON EXISTING COMPANIES, ORGANIZATIONS AND INDIVIDUALS
- ORGANIZED STIMULATION OF INTERACTION AND PLANNING WITHIN AND BETWEEN SECTORS
- RESOURCE INDUSTRY FOCUSSED, TECHNOLOGY DRIVEN CENTRES OF EXCELLENCE
- VALUE ADDED PRODUCTS FROM RESOURCES USING TECHNOLOGY DEVELOPED IN B.C.
- DEVELOP THE MARKETING, MANAGEMENT AND TECHNICAL TALENTS OF OUR PEOPLE
- EFFECTIVE USE OF SIGNIFICANTLY MORE R&D SPENDING

AGRICULTURE AND FOOD PROCESSING

PRIMARY AGRICULTURE
- ROLE OF AGRICULTURE CANADA
- VERY SMALL AVAILABLE LAND BASE

SECONDARY MANUFACTURE
- POTENTIAL GROWTH AREA

FOOD PROCESSING
- POTENTIAL GROWTH AREA

RECOMMENDATIONS

- INTERFACE WITH BIOTECHNOLOGY
  - DISEASE CONTROL
  - GENETICS
  - WASTE MANAGEMENT
- VALUE ADDED
  - FOOD PROCESSING
- INCREASE PRODUCTIVITY
- INCREASE INDUSTRY INVOLVEMENT
  - CO-OPERATIVE RESEARCH